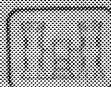


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## INVESTIGATION OF TIDAL POWER

### COBSCOOK BAY, MAINE



United States Army  
Corps of Engineers

*Serving the Army  
Serving the Nation*

**New England Division**

AUGUST 1980

#### NOTICE TO STUDY PARTICIPANTS

This report is a review draft and is subject to change. It is being circulated for in-house comments, corrections and changes by participating branches and agencies. This report is intended for study team review only and should not be released to the public.

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New England Power Planning (NEPOOL)  
Army Corps of Engineers - New England (NED)

INVESTIGATION OF TIDAL POWER  
COBSCOOK BAY, MAINE  
August 1980

EXECUTIVE SUMMARY

This report presents the results of a limited investigation into the feasibility of developing large scale tidal hydroelectric power facilities at Cobscook Bay, Maine. Since studies were first authorized by Senate Resolution in 1975, a series of investigations have been conducted dealing with the economic feasibility of developing a tidal power project. This study differs in that environmental baseline conditions are reported, potential social and environmental impacts are identified and consideration has been given to the marketing and integration of intermittent single pool tidal power into the existing New England electrical system.

Recently, a major change has occurred in the methodology used by Government agencies to determine the economic efficiency (benefit-to-cost ratio) of public power projects. The relative price shift methodology developed for the sensitivity analysis presented in earlier Cobscook Bay reports has been adopted by the Water Resources Council as an accepted method of testing the economic efficiency of a project. This investigation verifies earlier findings that certain tidal power projects within Cobscook Bay are economically efficient, that is, have benefit-to-cost ratios greater than unity, when analyzed within the relative price shift framework. The fundamental difference between this study and earlier studies is that this relative price shift demonstration of economic feasibility is more than an exercise in sensitivity analysis, it is a recognition of actual project economic feasibility. This recognition tacitly assumes that Department of Energy fuel cost escalation projections are correct, that oil will continue to be an important part of New England's electric generation, and that no major technological breakthroughs resulting in low energy costs will occur early in the project's life.

For this study four single pool alternatives were considered. Earlier studies indicated that single pool, single effect projects are capable of producing energy at lower costs than other configurations. The alternatives considered were located at Dudley Island, Goose Island, Birch Point and Wilson Ledges and ranged in size from 18 MW to 970 MW. After preliminary cost estimates were made, two alternatives were selected for further analysis, Birch Point and Goose Island. A summary of costs and benefits for the two projects is presented below.

Relative price shift energy benefits of 108 mills/Kwh were provided by the Federal Energy Regulatory Commission (FERC). No capacity credit has been taken at this time. Detailed studies may be undertaken at a future time to determine whether value should be associated with tidal project capacity.

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<u>Location</u>	<u>Birch Point</u>	<u>Goose Island</u>
Installed Capacity	165 MW	195 MW
Dependable Capacity	0	0
Annual Generation	560,000,000 KWH	660,000,000 KWH
First Cost of Tidal Power Project (August 1980)	\$675 800,000	\$734,300 000
Annual Cost Including Trans- mission (7-1/8%, 100 years)	53,213,000	57,658,000
Annual Benefit Including Energy at 108 mills/Kwh and Employment Benefits	63,715,000	74 083,000
Benefit-to-Cost Ratio	1.2 to 1.0	1.3 to 1.0

In spite of the intermittent nature of single pool tidal power, New England's power planning group (NEPOOL) has indicated that tidal power could be integrated and utilized within the New England system. According to current estimates by FERC, it appears that the tidal project will displace oil-fired generation.

The question of financial feasibility has been addressed, but it is unresolved. For a project to be financially feasible, the power produced must be sold at a rate that will allow the Federal Government to recover its investment within 50 years, assuming an 8% rate of interest. The Corps of Engineers does not market power it produces. The Department of Energy (DOE) is responsible for marketing. Currently, the Southeast Power Administration (SEPA) is the DOE's agency most likely to market any power generated at Cobscook Bay. SEPA has determined that Cobscook Bay energy would have to be sold for 94 mills/Kwh using recent cost estimates in order for the Federal Government to recover its investment within 50 years. Based on existing market conditions (energy costing about 50 mills/Kwh), SEPA determined that there would be no market for tidal energy. However, no attempt has been made to ascertain what market conditions will exist in 1995. Using relative price shift analysis and DOE fuel price projections, FERC has estimated that the real cost of energy (excluding general inflation) will be 108 mills/Kwh in 1995. If this estimate proves to be correct, a rate of 94 mills (excluding general inflation) would be relatively attractive. However, at this time, a relative price shift analysis has been undertaken for financial analysis.

Environmental evaluations presented in this report provide information for the Cobscook Bay area as a whole. Impact analysis is generic in nature. This approach was taken as the operational modes of the various dam alignments have not been finalized. Should further studies be

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authorized an intensive analysis of the impacts due to the development of tidal power in Cobscook Bay will be carried out.

A tidal power project would result in major impacts on the marine, estuarine, and riverine systems in the project area. Any alterations to these systems would affect circulation, salinity, sedimentation, temperature, shoreline erosion, flushing, ice formation, and nutrient levels. Nutrient and sediment supply would be reduced in intertidal areas and beaches, which, in turn, would result in significant alternations in the estuarine biota.

Commercially important invertebrates that are found in the Cobscook Bay area include: soft-shell clams, blue mussels, sea scallops, American lobsters, rock and Jonah crabs, northern shrimps, blood worms and sand worms. Impacts on benthos due to construction activities would occur during dredging and filling operations. The presence of large tidal dams would cause an increase in sedimentation due to the reduction in the tidal regime, as well as loss of mixing within the water column would affect the existing organisms.

Nine species of marine mammals are common to the Gulf of Maine and the Cobscook Bay area, and includes the fin, minke, humpback and right whales, the harbor porpoise, the harbor seal, and gray seal. Impacts on these mammals during construction would most likely be minor; however, the larger mammals would be very much restricted in their movement into and out of the bay once the facilities are in operation.

Those species observed in the Cobscook Bay area which are on the Endangered Species List of the Endangered Species Act of 1973, and which would require consultation under Section 7 of the Act are: the fin, humpback, right, sei, blue, and sperm whales, the shortnose sturgeon, the bald eagle, and the Arctic peregrine falcon. Cobscook Bay is the most important nesting area of the bald eagle, with approximately 20 to 25% of the total production of eagles in the northeastern United States occurring around the bay.

There are no Federally listed endangered plant species in the Cobscook Bay area.

All fish species found in the bay area are important biologically in the overall trophic ecology of the region. A major concern would be the effects of tidal power on the feeding and reproduction of the various species. Some depend on the intertidal benthic organisms as their main food source. The food source would be adversely affected as a result of the reduction of the intertidal zone due to the project implementation.

Impacts on the terrestrial environment would be those associated with transmission line construction and maintenance, and dam and access road construction. The general area studied by the Department of Energy (Bonneville Power Administration) is between Cobscook Bay and the Bangor area and is approximately 100 miles long and 50 miles wide.

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Impacts associated with bird and wildlife populations would depend upon their relationships and associations with the marine habitat they depend on for food. Populations could be displaced to other areas in search of food and shelter which would put pressure on the existing populations.

The most significant socioeconomic impacts associated with the project are expected to occur during project construction. The influx of up to 2,000 workers will tax existing local services and housing severely. The construction activity itself will disrupt many aspects of life in the project area. Increased traffic, noise and activity in the area will be evident over the anticipated five-year construction period. Long term socioeconomic impacts are expected to take the form of a general increase in socioeconomic activity. The three most important long term impacts known at this time are: increase tourism in the project area, the possibility of a shorter land route between Lubec and Eastport via a highway over the dams (60 miles reduced to 1 mile) and the addition of 500,000,000 to 700,000,000 kilowatt hours of electric energy to New England's electric system for a native, renewable resource.

The tidal power project has been found to be economically feasible using current Water Resource Council criteria, no insurmountable environmental impacts or technical problems have been identified, relatively favorable long-term socioeconomic impacts have been identified and it appears that a tidal power project would reduce New England's (and the Nation's) dependence on oil while increasing energy independence.

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## I. INTRODUCTION

### Purpose and Authority

This is a report on the feasibility of constructing a large tidal hydroelectric facility in the vicinity of Passamaquoddy Bay at Cobscook Bay near Eastport, Maine. Basic authority for this study is derived from a Resolution adopted on 21 March 1975 by the Committee on Public Works of the United States Senate and from subsequent directives from the Office of the Chief of Engineers. The Resolution is shown below and the directives are shown in the correspondence appendix.

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under the provisions of Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby, requested to review the report on Passamaquoddy-St John River Basin Power Project, Maine, transmitted to Congress by the President of the United States on July 12, 1965 published as House Document No. 236, 89th Congress, and other pertinent reports, with a view to determining the current feasibility taking full advantage of the latest technological advances, of the Passamaquoddy Tidal Power Project in the interest of providing tidal power, recreation, economic development and related land and water resources purposes.

### Scope of Study

The principal thrust of this study is the determination of whether it is economically feasible to develop a large Tidal Power facility at Cobscook Bay in Maine. This study, however, is not limited to economic issues as past studies have been. Environmental, marketing and other aspects of tidal power projects have also been addressed. Also since this study is intended to look at a specific type of project, namely a tidal hydroelectric project, efforts to study solar, wind, hydropower and other alternatives have not been made. The study is essentially a reconnaissance effort, although in some areas the study has gone into more detail. This document should be regarded as an "expanded reconnaissance report."

### Study Participation and Coordination

Study participants and brief summaries of their activities are presented below:

- U.S Army Engineer Division, New England - provided study management, coordination, hydropower estimates, design, and cost estimates for civil works, environmental, economic, social and marketing discussions, and prepared the report.

- U.S. Department of Energy, Federal Energy Regulatory Commission - provided preliminary conventional and final real fuel cost escalation power values.
- U.S. Department of Energy, Bonneville Power Administration - provided preliminary designs and estimated costs for transmission lines and substations.
- U.S. Department of Energy, Southeast Power Administration - provided a financial analysis and comments on marketability of tidal power.
- U.S. Department of Interior, Fish and Wildlife Service - furnished data from its Coastal Characterization Study and Generic Environmental Assessment for a tidal power project.
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Region - provided an environmental assessment and evaluation.
- University of Maine, Orono, School of Forest Resources - prepared a report entitled "Habitat Utilization by Southward Migrating Shorebirds in Cobscook Bay, Maine, during 1979."
- University of Maine, Orono, Project for Balanced Growth for Maine - conducted initial public meetings and a Symposium of Relative Price Shift Analysis.
- Passamaquoddy Indian Tribe, Pleasant Point Reservation, Half Moon Cove Tidal Power Project - provided comments on the study and participated by coordinating their study.
- Stone & Webster Engineering Corporation - provided recommendations as to size and type of turbines for the project and provided preliminary cost estimates for a typical powerhouse and generating equipment.
- New England Power Planning (NEPOOL) - provided basic system data and comments on system intergration of tidal power.
- State of Maine - State agencies provided input and comments on various aspects of the study.

#### The Report and its Organization

This report is divided into three parts; the main report, the environmental appendix, a combined correspondence and public involvement appendix, and a technical appendix. The main report discusses all aspects of the study in sufficient detail to allow the reader to formulate opinions. The appendices provide most of the data on which the main report is based.

The report is structured as follows:

#### EXECUTIVE SUMMARY

- I Introduction
- II Problem Identification
- III Formulation of Plans
- IV Assessment and Evaluation of Plans
- V Conclusions
- References
- Correspondence

and three separate appendix documents.

- Environmental
- Technical
- Public Involvement/Correspondence

#### Other Studies

Since 1920, when Mr. Dexter P. Cooper first analyzed the potential for tidal power, the Passamaquoddy-Cobscook area has been studied extensively. In 1935, the Corps of Engineers actually started construction of a tidal power project in Cobscook Bay during President Roosevelt's tenure. From 1948 to 1961, engineering and economic feasibility of a tidal power project in the Passamaquoddy Bay area was studied and reviewed by an International Engineering Board. From 1963-1965, the U.S. Department of the Interior, in conjunction with the Corps of the Engineers, reviewed and refined prior studies. Also, since 1973 the New England Division, Corps of Engineers, has intermittently reviewed the economic and engineering feasibility of various tidal power projects in the region.

If the Cobscook Bay Tidal Power Project had been built in 1936, the estimated annual cost over its 100-year life would have been 2.4 million dollars. The cost of energy from that project (which would have produced 308,000,000 kwhr annually) would have been 7.8 mills/kwhr. This is quite low when compared to today's production costs.

In 1976 (reference 30) the Corps, using the traditional form of economic (benefit/cost ratio) analysis, reported that the cost of building and operating a large, tidal installation in this region would exceed the benefits. The same conclusion was reached in a separate report (reference 39) compiled by the Department of Energy (formerly the Energy Research and Development Administration - ERDA) in early 1977. This was based on the benefit/cost ratio which results from comparing a project's estimated annual power benefits; i.e., the cost of producing needed power by an alternative means, with total annual project costs: i.e., operation, maintenance, major equipment replacements and initial investment amortized. For a project to be justified economically, the annual benefits would have to be either equal to or greater than the annual costs. Since

the purpose of the tidal project is to produce power, its justification should be based on power benefits. Currently, the benefit to cost ratio for the 1935 alternative based on 1 January 1979 price levels is estimated to be about .35 to 1.00.

After the 1976 study, due to the energy situation and rising cost of fossil fuel generating alternatives, former Governor Longley of Maine suggested the feasibility of tidal power be re-evaluated based on "life cycle" costing.

In response to the governor's request, dated September 7, 1976, (correspondence appendix), the Corps performed a preliminary life cycle cost analysis of the international Passamaquoddy Tidal Power Project (reference 30). Separately and concurrently, a preliminary life cycle cost analysis was also prepared by ERDA (reference 39) for one of the Cobscook Bay alternative projects. The two independent studies arrived at similar conclusions, which indicate that the projects were economically feasible when viewed from this method of analysis.

To the extent that the initial life cycle cost analysis included general inflation in the escalation rates utilized, it was not in accordance with the Water Resources Council's Principles and Standards. Therefore, the Office of the Chief of Engineers directed New England Division to conduct a similar analysis excluding general inflation (correspondence appendix).

Following the completion of the initial life cycle analysis, the Canadian Government was contacted and the results were presented (correspondence appendix). On 10 May 1978, the Canadian Government formally indicated by letter that it did not wish to participate in further joint studies in the Passamaquoddy region. Therefore, in subsequent studies international plans have not been considered.

In 1979, a preliminary economic study using an inflation free relative price shift analysis was accomplished for several possible tidal power alternatives located entirely within Cobscook Bay (reference 33).

Projects considered ranged from 4 megawatts to 450 megawatts of installed capacity. Single pool and multipool projects were analyzed. The projects were considered based solely on economic criteria. The study concluded that none of the alternatives considered were economically efficient using conventional, static, benefit to cost analysis. However, several large single pool projects were found to be economically justifiable assuming various fuel price escalation rates and utilizing relative price shift analysis.

Since the 1979 study did not address power integration or environmental concerns the Office of the Chief of Engineers directed that a more complete study be accomplished (correspondence appendix). The results of this study are presented in this report.

Currently two other significant studies are being conducted in the vicinity of Cobscook Bay. One is a smaller tidal power project at Half Moon Cove in Cobscook Bay and the other is a large oil refinery at Shackford Head in Cobscook Bay.

The smaller tidal power project is being studied by the Passamaquoddy Indians with funding from the Department of Energy. Currently a 10 MW facility with annual generation of 38 GWH is planned. If this facility and certain large tidal power alternatives at Cobscook Bay were both built modifications to the smaller project would be necessary to make them compatible.

The other project is a 250,000 barrel per day refinery currently being planned by the Pittston Company of New York. If this project were built along with certain large tidal power alternatives, very large locks would have to be included as part of the tidal power project to accommodate tankers.

It should be noted that final decisions to build either the refinery or the Half Moon Cove tidal power project have not been made and that the future of these projects is uncertain.



## II. PROBLEM IDENTIFICATION

### National and Regional Objectives

The primary objective of the tidal power projects under consideration is to reduce the region's (and Nation's) dependence on foreign oil for energy generation. Currently in New England 50% to 60% of the region's annual energy requirements are met using oil fired generating facilities. A tidal power project would displace oil generated energy, reduce dependence on foreign oil and keep U.S. dollars in the United States. Any tidal power plan developed would have to be technically, environmentally, economically and socially acceptable.

### Existing Conditions in the Study Area

#### Physical Setting

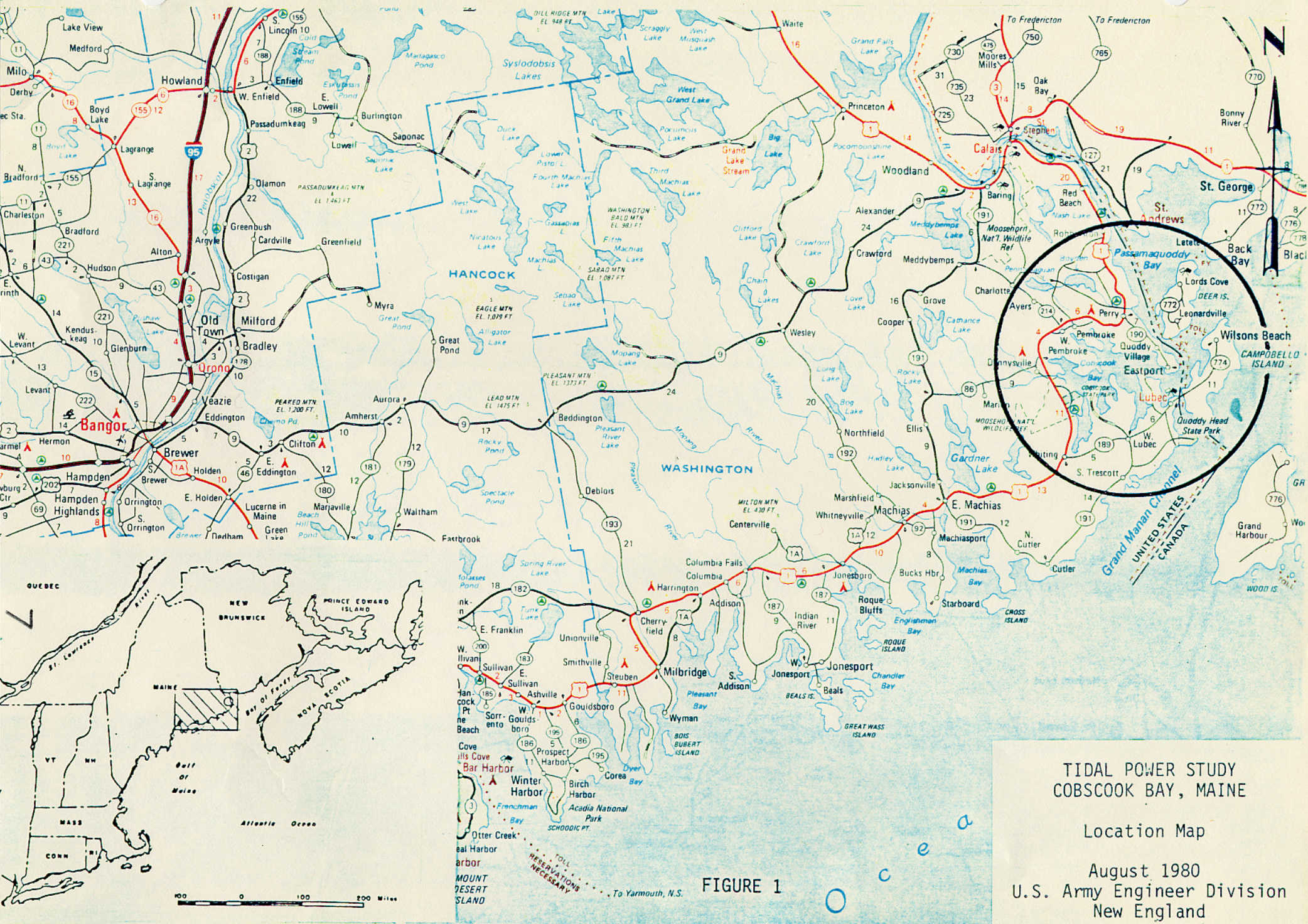
The study area is located about 300 miles northeast of Boston and about 50 miles east of Bangor, in Washington County, Maine. Washington County is the most easterly county in the United States. Eastport and Lubec are the two largest shoreline communities. Other smaller shoreline communities include Perry, Pembroke, Edmunds, Dennyville, Whiting and Trescott (See Figure 1).

Cobscook Bay, located entirely in the United States, drains an area of approximately 400 square miles and has a surface area of about 39 square miles at high tide (See Figure 2). Depths in the bay range to 150 feet below the National Geodetic Vertical Datum (formerly known as "mean sea level"). The bay's many peninsulas, coves and internal bays create the opportunity to consider various tidal power alternatives. These irregularities give the bay a shoreline that is about 230 miles long. This long shoreline in conjunction with the large tide range results in about 7 square miles of intertidal mudflats (see Figure 3). The three most significant streams flowing into Cobscook Bay are the Dennys, Pennamaquan, and Orange Rivers. These drain 130, 45 and 35 square miles, respectively. The Dennys River is the only gaged stream within Cobscook Bay's drainage. It has an average annual discharge of 190 cfs.

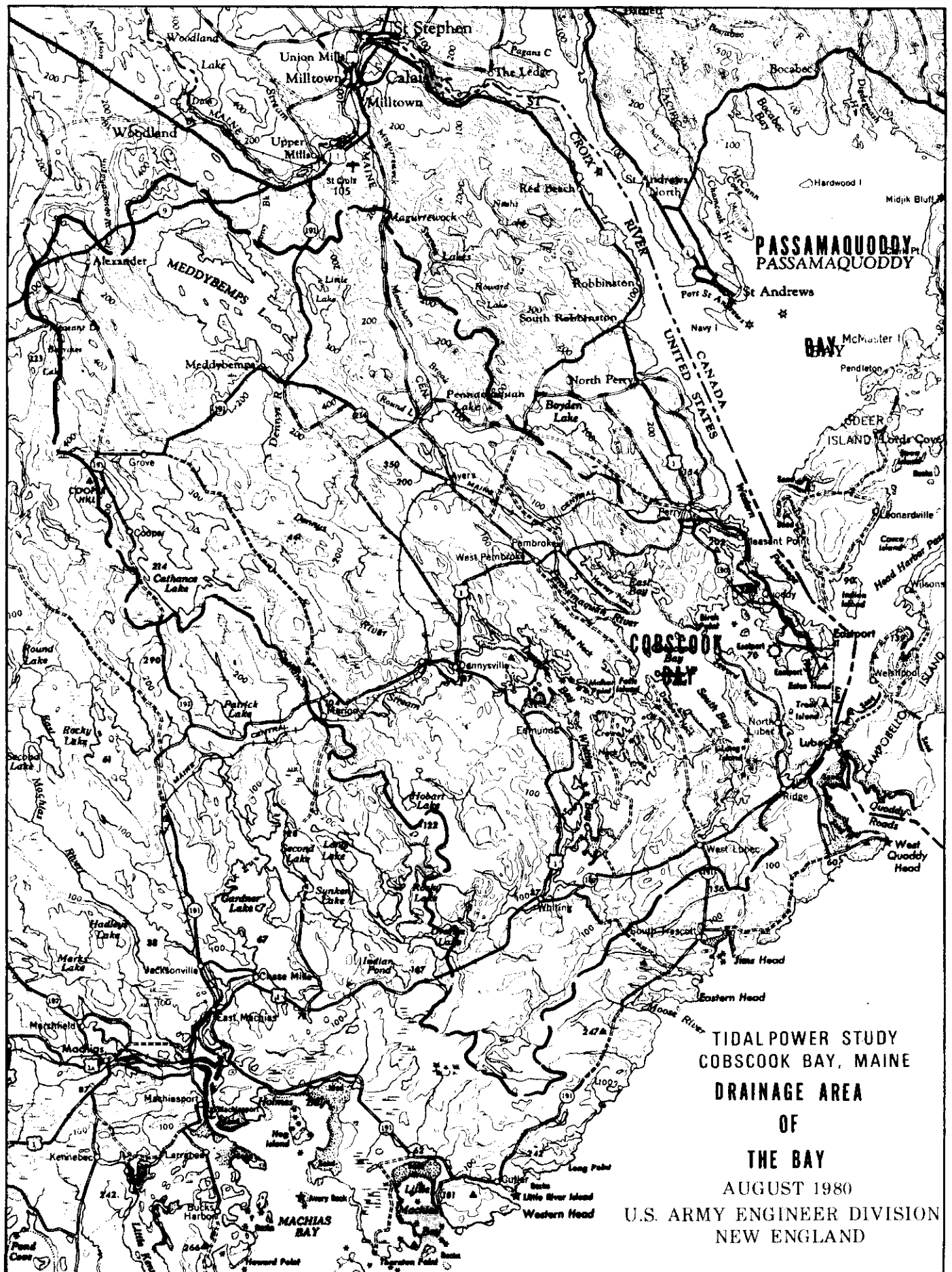
The tidal range, affected primarily by the phases of the moon varies from day to day. The time of occurrence of high and low tide also varies daily, owing to the fact that the 12 hour and 25 minute lunar cycle controls the tides while the 24 hours solar cycle is by definition the base for our solar day. Located at the mouth of the Bay of Fundy the range of tides in Cobscook Bay vary from a minimum of 11.3 feet at neap tide to a maximum of 25.7 feet at spring tide, averaging 18.1 feet. During each tidal cycle an average volume of approximately 17 billion cubic feet of water regularly enters and leaves the bay.

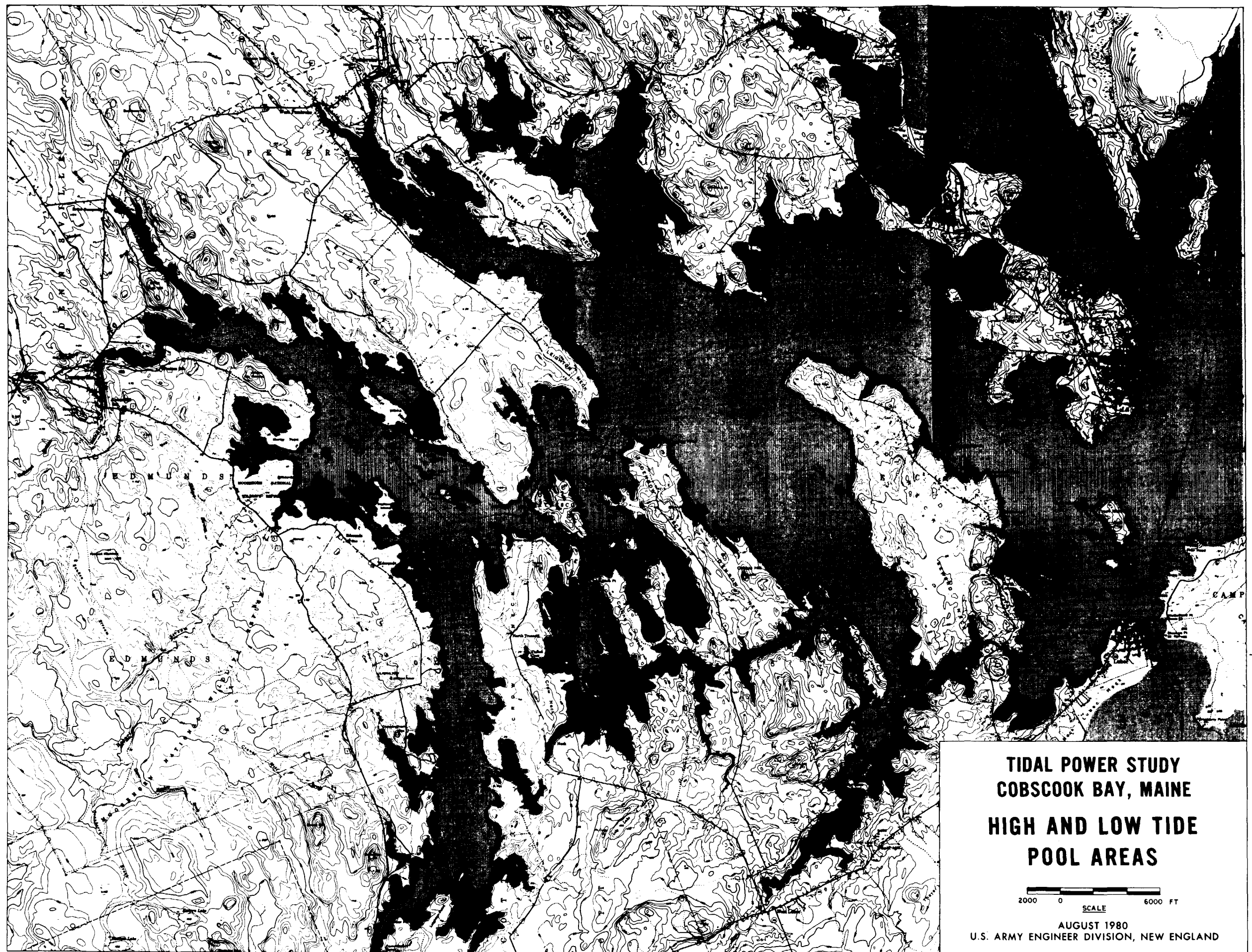
Onshore breezes blow several miles inland along the coast, bringing cooling trends in the summer and warming trends in the winter. The











Labrador current flowing southward along the Nova Scotian coast brings cold water into the Gulf of Maine. This contributes to the abundance of precipitation and the prevailing westerly winds. Average temperatures range from 60°F in the summer to 15°F in the winter. Severe fog is often encountered especially during dark hours of summer months. The average annual precipitation is 43 inches and the average snowfall is 70 inches. This results in an annual runoff of about 28 inches per year from the bay's 400 square mile drainage area.

Water temperature ranges seasonally from about 1 to 13°C; salinity throughout the bay varies from 31 to 33. Dilution of bay waters by freshwater inflow is minimal. Consequently, Cobscook remains relatively ice-free during winter.

Cobscook Bay can be considered to be divided into two bays at the Falls Island constriction (Reversing Falls), an outer bay which responds to tide changes similar to the ocean and an inner bay which behaves somewhat differently. Generally, tidal changes in the inner bay lag the outer bay by one and one-half hours. Maximum differences between inner and outer pool elevations of as much as eight feet have been observed. Flow rates exceeding 200,000 cfs typically occur at the restriction and currents exceeding 9.5 ft/sec have been observed. In the outer bay around Shackford Head tidal currents of about 5.0 ft/sec have been observed where mean current velocities are 3.0 ft/sec.

Water quality in the bay and its freshwater tributaries is generally very good. Detailed information on water quality is presented in the Environmental Appendix to this report.

The Cobscook Bay area is located in the extreme northeasterly corner of the United States and is part of the Appalachian province which includes a region of mountainous and coastal lands and waters extending from Alabama to Newfoundland. The region, in general, is characterized by low, bedrock hills and wide, flat plains with long, marine estuaries occupying the lower parts of the coastal valleys. The unique distribution of land and water which makes up Cobscook Bay is the surface expression of a thick succession of Silurian volcanic and sedimentary rocks that have been folded into a broad northeastwardly plunging anticline bordered by a northeast trending faults. The barriers across this bay consist of the folded resistant rock of the Silurian succession. At the International Boundary a major fault which strikes north, northwest along the St. Croix River Channel is assumed to extend continuously for 30 miles from Campobello Island to Oak Bay.

The overburden in the region consists primarily of glacial till and marine sediments. Glacial till is generally found directly overlying the bedrock and is exposed on the tops and slopes of some of the higher bedrock hills. In many places the till was subjected to wave action while the region was submerged and was either removed from the rock or reworked to form poorly developed beach deposits, which now mark former elevations of sea level. Overlying the till in the valleys are deposits of sand and



gravel outwashed from the retreating glacier when its front stood close to the present shore line. After the glacier had melted back some distance from the coast, silt and clay were laid down over the previous sediments in all the lowlands to an elevation of approximately 100 feet above sea level. Uplifting since glacial times has caused the emergence of much of the pre-glacial land masses but the drowned river valleys and islands of the Cobscook Bay Region show that much of the old land is still submerged. Wave and current action in the existing rivers and bays had built up recent deposits of sand and silt which blanket the older deposits of marine clay.

The Cobscook Bay area is located in Zone 1 of the Seismic Probability Chart for the United States. The seismic map indicated that damage in this zone would be minor. However, a cursory review of available historical data reveals that approximately 30 earthquake epicenters have been recorded within a 75 mile radius of the project area. In 1978, two solar powered seismic array stations were established by the Corps of Engineers about 20 miles west of the project site to monitor seismic activity in the Cobscook Bay region. Since the installation there has been no significant activity recorded at the stations which have been continually monitored at the Weston Observatory in Weston, Massachusetts.

Recent published reports on crustal subsidence in eastern Maine and measured by the comparison of vertical leveling between Bangor and Calais, Maine, coupled with the geological and historical data indicates that the coastal zone is warping downward towards the east. Between 1942 and 1966 the relative subsidence was up to 175 mm (6.94 inches). This is considered a minimum figure. Recent studies in 1979 have reportedly reconfirmed these values.

The mineral resources of the project area are composed of lead, zinc, and copper, none of which are commercially developed at the present. The Bureau of Mines Minerals Yearbook of Maine for 1976 lists the mineral produced for Washington County as sand, gravel, peat and stone in that order of value.

The land surrounding the bay is rocky and hilly with many streams, lakes and bogs. Agricultural lands including blueberry barren are present. Most of the forested area consists of softwoods or mixed hardwoods and softwoods. The forest cover is second growth timber. The virgin forest has either been logged or destroyed by fire in past years. Softwoods found in the area include spruce, fir, pine, hemlock, cedar and tamarack. Hardwoods include birch, aspen, maple and beech. Alders are usually found near the water bodies. Plants typical to northern Maine are found in the area. Seaweeds, kelps, rock weeds, eelgrass and macroalgae abound. Many ferns are present.

Those palustrine classes identified by the National Wetlands Inventory which can be found within the Cobscook Bay area include the following: marine subtidal/open water, marine subtidal/unconsolidated bottom, marine

intertidal/beach/bar, marine intertidal/flat, marine intertidal/rocky shore, marine intertidal/aquatic bed, estuarine subtidal/unconsolidated bottom, estuarine intertidal/beach/bar, estuarine intertidal/flat, estuarine intertidal/rocky shore, estuarine intertidal/aquatic bed, estuarine intertidal/emergent, estuarine subtidal/rock bottom, and estuarine subtidal/open water.

Saltmarshes are the most common vegetation along the edges of Cobscook Bay, being inundated with salt water at each high tide, and are made up of tidal creeks and emergent vegetation. The channels are dominated by saltmarsh cordgrass (Spartina alterniflora).

Macroalgae or seaweeds, are the most abundant form of marine vegetation found in the area. Brown, red, and green algae are common along the shore and in the intertidal and subtidal areas of the bay. Brown algae are dominant in the rocky intertidal and subtidal plant communities. The rockweeds Ascophyllum and Fucus are dominant intertidal species, while the kelps Laminaria and Agarum dominate the subtidal areas. These communities provide habitat for a large number of marine and estuarine animals. Cobscook Bay has a high density of sea urchins who graze heavily on the macroalgae. Fish also graze on macroalgae. Other marine vegetation consists of eelgrass beds which can be found throughout the Bay. The production of seaweeds and eelgrass is extremely high in Cobscook Bay, and is very significant in the trophic ecology of the region (reference 43).

#### Environmental Setting

As a result of low human activity and the presence of almost all types of wildlife habitat, the area has a rich diverse fauna population. White tailed deer, moose and black bear are present. Small mammals commonly found include bobcat, snowshoe hare, red fox, red squirrel, porcupine, muskrat, beaver, raccoon and meadow vole. Upland areas contain habitat for woodcock, grouse and a variety of songbirds, hawks and owls. Waterfowl that utilize both inland and coastal waters include black duck, ring-necked duck, teal, wood duck, goldeneye, bufflehead, scoters, mergansers and Canada geese. Bald eagles and osprey are present and depend heavily upon the marine resources found in the bay. Although reptiles and amphibians are not abundant in Maine, the marshes, bogs and rivers present in the study area may support a high number of certain species. Coastal Maine is inhabited by sixteen amphibian species and fourteen reptile species. There are no native lizards in Maine. Factors that may affect the abundance and distribution of reptiles and amphibians include agriculture, population, small impoundments, and any other disturbances to the land, water and forest. Little information is available concerning reptiles and amphibians that inhabit the Maine coast. Table 2 is a list of wildlife known to be present in the study area. The list is taken from data gathered by the U.S. Fish and Wildlife Service for its Coastal Characterization study recently completed within the study area (reference 42).

Table 1 Wildlife in the Study Area

Mammals

Marsupialia  
 Virginia opossum  
 Insectivora  
 Masked shrew  
 Water shrew  
 Smokey shrew  
 Thompson's pygmy shrew  
 Short-tailed shrew  
 Hairy-tailed mole  
 Star-nosed mole  
 Chiroptera (Bats)  
 Little brown bat  
 Keen's myotis  
 Small-footed myotis  
 Eastern pipistrelle  
 Big-brown bat  
 Red bat  
 Hoary bat  
 Norway rat  
 House mouse  
 Meadow jumping mouse  
 Woodland jumping mouse  
 Porcupine  
 Artiodactyla  
 White-tailed deer  
 Moose

Lagomorpha (Rabbits and Hares)  
 New England cottontail  
 Showshoe hare

Rodentia  
 Eastern chipmunk  
 Woodchuck  
 Gray squirrel  
 Red squirrel  
 Southern flying squirrel  
 Northern flying squirrel  
 Beaver  
 Deer mouse  
 White-footed mouse  
 Gapper's red-backed vole  
 Meadow vole  
 Pine vole  
 Muskrat  
 Southern bog lemming

Carnivora  
 Coyote  
 Red fox  
 Grey fox  
 Black bear  
 Raccoon  
 Marten  
 Fisher  
 Erine  
 Long-tailed weasel  
 Mink  
 Striped skunk  
 River otter  
 Bobcat

Herptiles

Salamanders  
 Blue-spotted salamander  
 Spotted salamander  
 Red-spotted newt  
 Northern dusky salamander  
 Red backed salamander  
 Northern two-lined salamander  
 Frogs and Toads  
 American toad  
 Spring peeper  
 Gray tree frog  
 Bullfrog  
 Green frog  
 Northern leopard frog  
 Pickerel frog  
 Mink frog  
 Wood frog

Turtles  
 Snapping turtle  
 Wood turtle  
 Eastern painted turtle

Snakes  
 Northern water snake  
 Northern brown snake  
 Red-bellied snake  
 Eastern garter snake  
 Northern ringneck snake  
 Northern black racer  
 Smooth green snake  
 Eastern milk snake

## Birds

Mouring dove  
Black billed cuckoo  
Common flicker  
Eastern kingbird  
Alder flycatcher  
Blue jay  
Grey catbird  
Brown thrasher  
American robin  
Ruby crowned kinglet  
Starling  
Nashville warbler  
Yellow warbler  
Magnolia warbler  
Chestnut-sided warbler  
Common yellow throat  
Common grackle  
Great blue heron  
Black bellied plover

Brown head cowbird  
Cardinal  
Indigo bunting  
American goldfinch  
Rufous sided towhee  
Savannah sparrow  
Vesper sparrow  
Dark eyed junco  
Chipping sparrow  
Field sparrow  
White throated sparrow  
Song sparrow  
Bald eagle  
Sandpiper  
Herring gull  
Ring-billed gull  
Sanderling  
Dowitcher

## Waterfowl

Black duck  
Mallard  
Common goldeneye  
American eider  
Hooded merganser  
Canada goose  
Greater scgup  
Bufflehead  
Old Squaw  
Harlequin  
King eider  
White winged scoter  
Surf scoter  
Black scoter  
Red-brested merganser  
Barrow's roldeneye  
Lesser scaup

Wood duck  
Ring necked duck  
Blue-winger teal  
American green winged teal  
Whistling swan  
Brant  
White fronted goose  
Gadwell  
Pintail  
European widgon  
American wiidgeon  
Lesser snow (blue) goose  
Greater snow goose  
Northern shoveller  
Ruddy duck  
Fulvous whistling duck  
Canvasback

## Marine Mammals

Harbor porpoise  
Pilot whale  
White side dolphin  
Fin whale  
Minke whale  
Humpback whale  
Right whale

Killer whale  
Bottlenosed dolphin  
Gray grampus  
Striped dolphin  
Beluga  
Sei whale  
Blue whale

Marine Mammals (Continued)

Harbour seal  
Grey seal  
White beaked dolphin  
Common dolphin

Sperm whale  
Pygmy sperm whale  
Northern bottlenosed whale

Fish

Atlantic salmon  
Alewife  
Rainbow smelt  
Striped bass  
Brook trout  
American eels  
Rainbow smelt  
Shortnose sturgeon  
Flounder

Redfish  
Cod  
Pollock  
Tomcod  
Herring  
Haddock  
Sand dab  
Rock eel  
Mackerel

Benthic Organisms

Softshell clam  
Blue mussel  
Sea scallop  
Lobster  
Rock crab  
Jonah crab  
Northern Shrimp

Blood worm  
Sand worm  
Periwinkles  
Sea urchins  
Chitons  
Limpets

Rare And Endangered Species

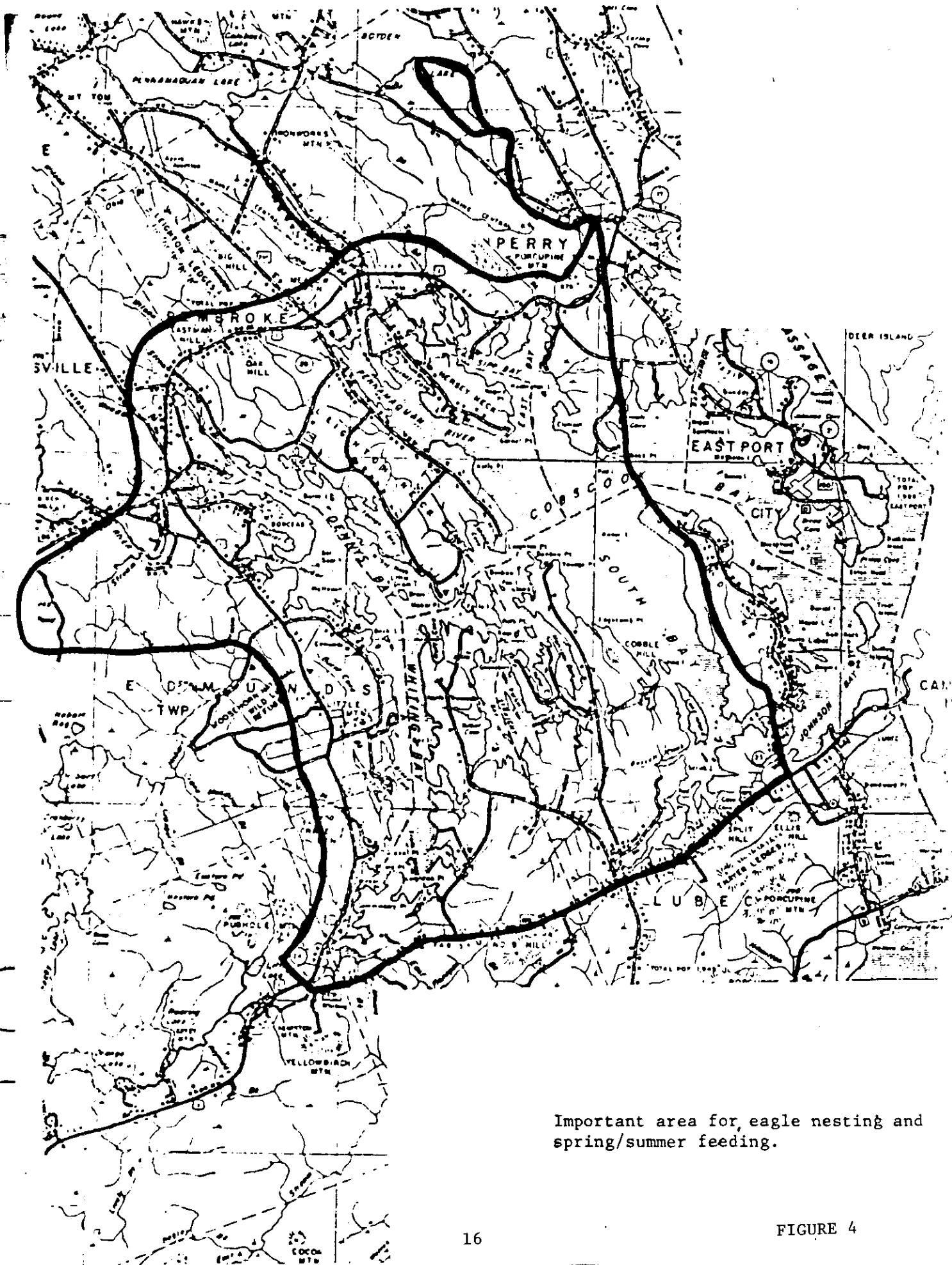
As can be seen from Table 1 above, the study abounds with wildlife.  
Rare and endangered species which are found in the area are listed in Table 2.

Table 2 Rare and Endangered Species  
Found in the Study Area

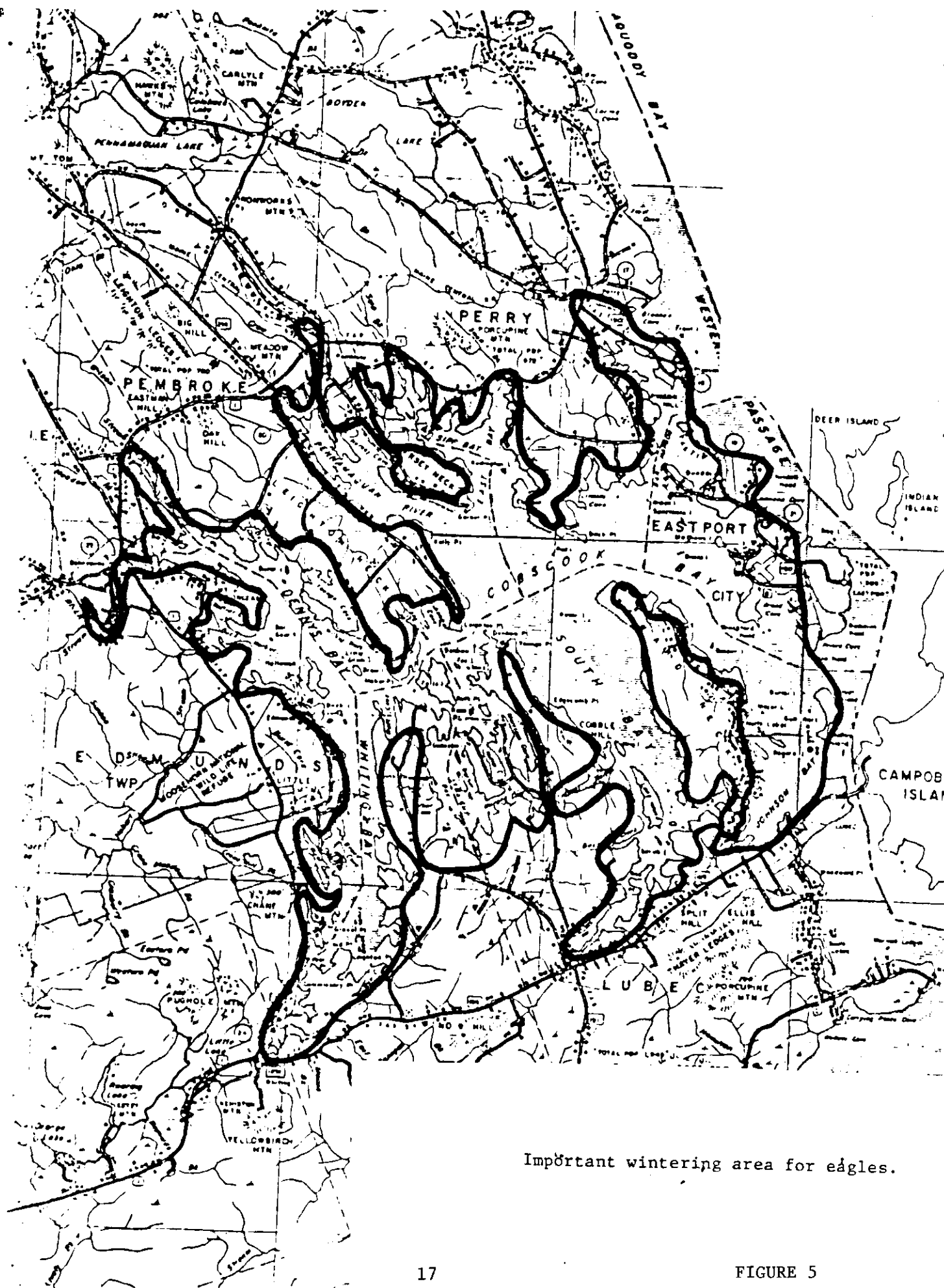
Bald Eagle  
Fin Whale  
Humpback Whale  
Right Whale  
Sei Whale  
Blue Whale  
Sperm Whale  
Shortnose Sturgeon  
Atlantic Peregrine Falcon

Cobscook Bay is a very important nesting area for the bald eagle (Haliaeetus leucocephalus), with approximately 20 to 25% of the total production of eagles in the northeastern U.S. occurring around the bay.





Important area for eagle nesting and spring/summer feeding.



During 1978 17 intact nests were found, with eight being occupied, and four producing young (reference 43).

Important nesting and spring/summer feeding areas for bald eagles includes all of Cobscook Bay except for outside Seward Neck/Birch Point with all of the bay being significant in the winter (Figures 4 and 5). Eagles that nest in the area occasionally remain during the winter as the ice-free water attracts waterfowl, which serves as an important part of the eagle's winter diet.

The Arctic peregrine falcon (Falco peregrinus tundrius) is a transient during spring and fall migrations. There are, however, no defined migration corridors or concentrations of peregrines in the area (reference 43).

There are no Federally listed endangered plant species in the Cobscook Bay area. The monkey-flower (Mimulus ringens var. colpophilus) is on the list of Smithsonian Institutions Endangered and Threatened Plants of the U.S. Three species that are considered critical in Maine include the bird's eye primrose (Primula laurentiana), beachhead iris (Iris hookeri), and roseroot (Sedum rosea). These are arctic species whose southernmost range is the northeast coast of Maine. Intensive surveys may reveal the presence of these species.

The following vascular plant species have been reported to be present at stations in Washington County. They are considered rare by the New England Botanical Club (NEBC) as reported in the 1978 publication entitled: "Rare and Endangered Vascular Plant Species in Maine." However, the presence of these plants is questionable as some stations date back to the 1800's.

As previously stated, it should be noted that, at present, none of these are on the Federal list of endangered plants for this area or are they being proposed for inclusion on this list.

Iris hookeri Penny - coastal ledges and beaches, Washington County

Arethusa bulbosa L. - Bogs - More common along the coastal zone

Betula caervlea - grandis Blanch - Mixed woods - Washington County

Geocaulon lividum (Richards) Fern. - Alpine barrens and coastal bogs  
Washington County

Nuphar microphyllum (Pers) Fern - Shallow water (fresh), occurring in northern half of the State.

Nymphaea tetragona Georgi - Shallow water (fresh), occurring in northern half of the State

Sedum rosea (L) Scop. Coastal ledges and beaches, Washington County

Rubus chamaemorus L. - Alpine barrens and coastal bogs, Washington County

Empetrum atropurpureum Fern & Wieg - Alpine barren and coastal bogs, Washington County

Kalmia latifolia L - Rocky woods, occurring from Washington County south

Primula laurentiana Fern - Ledges, Washington County

Mimulus ringens var colpophilus Fern - Fresh water estuaries - Washington County - on Smithsonian list

#### Marine Fisheries

Over 100 fish species have been recorded from the Quoddy Region (Linkletter et al., 1977). Most commercial fishing takes place outside Cobscook Bay, on the Perry Shore of Western Passage, specifically for herring. Herring processing actively takes place in the town of Eastport, with one packing and three processing plants in operation. Others include small fisheries for alewives and eels. No groundfish are commercially fished for inside Cobscook Bay.

The amount of recreational fishing that takes place is not known. Those species that are known to be taken include winter flounder, mackerel, redfish, cod, pollock, tomcod, and striped bass (reference 43).

Redfish (ocean perch) have commonly been observed feeding on the surface at Eastport. According to the National Marine Fisheries Service, this type of surface feeding is unique within its range, and has proposed that this area be designated a sanctuary under the Marine Sanctuaries Act (16 U.S.C. 1431-1434).

It has not been determined to what extent Cobscook Bay serves as a spawning and nursery area for fish. Larvae of the following species were found in plankton surveys done in 1960 by Legare and Maclellan: rock eel, sand dab, lumpfish, wrymouth, sea snail, cod, haddock, whiting, smelt, pollock, butterfish, winter flounder, hake and herring.

As the catch statistics pertain only to landings of fishes and not where the fish actually were taken, a definitive value of the fisheries resources can not be determined. However, neither Cobscook Bay nor Passamaquoddy Bay have significant commercially fishable resources (reference 27).

#### Benthic Organisms

The species diversity of benthic invertebrates is higher here than anywhere else along the Maine Coast due to the diversity of habitat,

nutrient supply, and the over-all trophic ecology of the region. Other factors may include the large tidal range, the counterclockwise circulation produced by local weather patterns and substrate types (reference 43).

As a result of some invertebrates in the bay being found only in the deeper waters of the Gulf of Maine, or are arctic species, the Maine State Planning Office has designated three critical areas in Cobscook Bay. They are Birch Islands, Crow Neck, and Wilburs Neck.

Commercially important invertebrates that can be found are: soft shell clam (Mya arenaria), blue mussel (Mytilus edulis), sea scallop (Placopecten magellanicus), American lobster (Homarus americanus), rock crab (Cancer irroratus), Jonah crab (Cancer borealis), Northern shrimp (Pandalus borealis), Blood worm (Glycera dibranchiata), and sandworm (Nereis virens).

Soft-shell clams and sea scallops are the most important commercially harvested invertebrates in Cobscook Bay. Though the intertidal flats support large populations of clams, there are factors that limit production in certain areas of the bay, such as tidal scouring and flocculent sediments, smothering by epibenthic algae, and limited access to clamming areas (reference 43).

Scallop beds that are significant are found in Whiting Bay, South Bay/Cobscook Bay, and Johnson Bay/ Srioi Roads.

Sandworms and bloodworms are harvested on the intertidal mudflats, mostly outside the Quoddy Region because of the softer sediments in that area. Some are harvested within the bay itself, although to a much lesser extent.

Lobsters are not harvested in sufficient quantities to support a significant commercial fishery (reference 43). This low production may be as a result of tidal scour, turbulence, siltation, poor food supply, predation, and extreme tidal range.

Other invertebrates that are harvested commercially include blue mussels, periwinkles and rock crabs. A limited year round fishery currently exists within the bay for periwinkles. However, these species do have the potential for commercial utilization depending upon market conditions.

According to a survey conducted for the Pittston Oil Refinery Impact Statement, 1978, (reference 41), worms were most numerous in the silt-clay subtidal areas, followed by chitons, clams, amphipods, the brittlestar (Ophiura robusta), and sea urchins. Snails were found in the rocky intertidal areas, and intertidal areas consisted of periwinkles, limpets, clams, and worms.

## Plankton

What little is known about planktonic organisms within Cobscook Bay comes from the International Passamaquoddy Fisheries Board Report to the International Joint Commission done by Leagare and MacLellan in 1959.

The predominant phytoplankters in Cobscook Bay are diatoms. Species include Thalassiosira, Chaetoceros, and Biddulphia, with their concentrations varying greatly from month to month.

Zooplankton is comprised mainly of copepods, with the most dominant species being Calanus finmarchicus, Pseudocalanus minutus, and Centropages typicus; most probably immigrating from the Gulf of Maine. Three species that are considered to be local in the region are: Tortanus discaudatus, Acartia clausi and Eurytemora herdmani (reference 27).

Other zooplankton is made up of eggs, larvae and juveniles of fish, crabs, euphausiids, mussels, barnacles, chaetognaths, and annelids. Legare and MacLellan identified 22 species of fish larvae in their survey.

## Marine Mammals

Nine species of marine mammals are common to the Gulf of Maine and the Cobscook Bay area, with another 12 species occurring rarely. Table 4 lists those mammals that can be found in the project area.

The harbor porpoise and harbor seal are the most common marine mammals in the area. The porpoise population found in Cobscook Bay may be the last healthy one in the Atlantic.

The fin, minke, humpback, and right whales can also be seen frequently, with the minke being the most common having a population of nearly 80,000 in the North Atlantic. The feeding habits of the various species of cetaceans differ among them, i.e., right whales will feed near the surface, humpbacks and minkes below the surface, while the fin whale will feed near the middle of the water column. Fin whales can be seen in nearshore waters from late spring to late summer, with humpbacks being farther offshore during the summer.

All these whales are baleen whales (those without teeth), and are the largest in the whale family. They feed somewhat on small fish, but their diet consists mainly of krill (planktonic crustaceans and larvae) and copepods that can be found throughout the water column.

The harbor seal and the gray seal occur in the area, with the harbor seal being more common. These seals, in addition to the harbor porpoises, utilize the Quoddy region for reproduction and as a nursery area. In summer and early fall, the harbor porpoise population may be centered in this region (reference 27). Harbor seals maintain a breeding population of several hundred in the bay, with local populations of both harbor seals and

porpoises depending upon the area for food and shelter throughout the year. In Region 6 of the Coastal Characterization Study, (reference 42), 30 harbor seal haulouts, and 2 gray seal haulouts sites were identified in the period of 1965-1976. Most of the marine mammals can be found in the area during the spring and summer, migrating to southerly waters in the fall.

#### Freshwater Fisheries

Freshwater fisheries in the Cobscook Bay area consist of diadromous fisheries in the coastal streams that flow into the bay. Anadromous fisheries include Atlantic salmon, alewife, rainbow smelt, striped bass, and sea-run brook trout. American eels, which are catadromous, can also be found in these streams. After growing to maturity here, they will migrate to the ocean to spawn.

The Dennys River is considered to be the most important Atlantic salmon river in the Cobscook drainage basin, supporting an annual run of up to 700 fish (reference 43). A factor influencing the migration of salmon is the annual water flow in the Dennys River itself. Should the runoff be low in dry years, salmon will remain in Dennys Bay until the fall, instead of running during the late spring and early summer.

In the spring, alewives will ascend the Dennys and Pennamaquan rivers for spawning. Those runs in the Dennys rivers are fished commercially by the towns of Dennysville and Meddybemps, while those in the Pennamaquan are fished by the town of Pembroke (reference 43). The Dennys and Pennamaquan rivers are also fished commercially for adult eels in their migration downstream to the ocean in late summer and fall.

Rainbow smelt are fished for sport also in the Dennys River during late April and early May. Striped bass are caught occasionally in the Dennys River, and sea-run brook trout are found primarily in the Orange and Pennamaquan rivers. A non-anadromous brook trout population exists in the Dennys River upstream from the estuary (reference 43).

The Shortnose sturgeon (Acipenser brevirostrum), is anadromous in some of the tributaries in the Gulf of Maine and Passamaquoddy Region and is listed as endangered on the Federal list of Endangered Species.

#### Avifauna

The intertidal areas of Cobscook Bay attract an extremely high density of shore and wading birds, with resident, breeding, wintering, and migrant species being found. The area is utilized for feeding and accumulating energy reserves for their migration to wintering areas in South America. The following species commonly found are semi-palmated sandpiper, eiders, cormorants, Bonaparte's gull, herring gull, great black backed gull, ring-billed gull, sanderling, black-bellied plover, semipalmated plover, least sandpiper, dowitcher and Great blue heron. Many of these birds can be found in the estuaries during their autumn migration.

Cobscook Bay also provides an important wintering area for waterfowl because of the lack of ice-cover. Common species include black ducks, bufflehead, old squaw, white-winged, black, surf scoters, and red-breasted mergansers.

Region 6 of the USFWS Coastal Characterization Study (reference 42), that includes Cobscook Bay has seven major seabird islands. The five most important islands are Old Man Island (east), Libby Island, Browney Island, The Brothers, and Flat Island. Old Man Island (east) has one of the only two U.S. razorbill colonies in the coastal zone. Machias Seal Island is an important area for arctic terns, common puffins, and also razorbills.

Two important seabird nesting sites in Cobscook Bay are Goose Island and Spectacle Island.

Glaucous and iceland gulls, which are winter residents, are found in the greatest numbers near Lubec and Eastport. The migratory Bonaparte's gull have high concentrations in the tens of thousands in Passamoquoddy Bay near Eastport.

Region 6 also has a large wintering population of purple sandpipers, remaining along the coast until April or early May. It contains 30 major feeding areas and 34 roosting sites.

The waters in the mouth of Passamoquoddy Bay near Eastport support approximately one-half to two million northern phalaropes annually.

Concentrations of semipalmated sandpipers are known to exist at Half-Moon and Carrying Place Coves, Lubec Narrows, and Machias Bay.

The Black Duck is the most numerous waterfowl species that overwinters in the region. The large tidal range results in extensive exposed flats that provide excellent feeding grounds for the black ducks. Occurring in moderate number during the winter are Common Goldeneye, Oldsquaw, Common Eider, and Red-breasted merganser. The occurrence of sea ducks is similar to that of the black ducks, however, their distribution varies by species.

Region 6 of the Coastal Characterization Study (reference 42), is also an important area for ringnecked ducks. Eider nesting colonies are present in large numbers, and migrating brant utilize this region as a stopover in their spring migration.

The habitat selection and specific food habitats of wintering waterfowl in the marine, estuarine, and riverine systems of the area are not well known (reference 42). Data gaps in the knowledge of waterfowl biology and ecology for the region includes the population status of the Black Duck and the Common Goldeneye, effects of pesticides and contaminants, coastal ice formation, and the ecological role of mergansers (reference 43).



## Cultural, Social and Economic Setting

### Demographic Trends

For the purpose of discussing social and economic issues the study area includes all of Washington County (Figure 6). Washington County occupies 2,554 square miles, 85 percent of which is forested land. Its 1975 population was 32,854 with a population density of 13 persons per square mile. This represents about 3 percent of the population of the State of Maine. The county's population increased 10 percent from its 1970 population of 29,859. This exceeds the 6.6 percent growth experienced by the state for the same period. Most of the county's residents live in the coastal areas. The five largest communities in Washington County lie within one hour's drive of the project area.

Census figures from 1930 to 1970 show the population of Washington County decreasing each decade from 37,826 in 1930 to 29,859 in 1970, a total loss of 21 percent. Meanwhile the State population for each decade between 1930 and 1970 registered an increase resulting in a total increase of 194,625 or 24 percent from 797,423. The decline in population in Washington County is due to its remote location, a reduction in full time employment opportunities, and a decline in industries, especially fisheries. A comparison of county and State population figures is presented in Table 3. The turnaround in population experienced between 1970 and 1975 (an increase of 10%) is attributed mainly to an influx of urban dwellers seeking new lifestyles.

Table 3  
Population Trends 1930-1975  
Washington County and State of Maine

	<u>Washington County</u>	<u>Percent Change From Preceding Decade</u>	<u>Washington County as Percent of State</u>	<u>State of Maine</u>	<u>Percent Change From Preceding Decade</u>
1930	37,826		4.7	797,423	
1940	37,767	-0.2	4.5	847,226	6.2
1950	35,187	-6.8	3.9	913,774	7.9
1960	32,908	-6.5	3.4	969,265	6.1
1970	29,859	-9.3	3.0	992,048	2.4
1975	32,854	10.0	3.1	1,057,955	6.6

Source: U.S. Census

The majority of in-migrants are young and middle-aged men and women, many married and some with children, according to a report by Louis A. Ploch of the University of Maine, called "Maine's New Pattern of In-Migration." "Quality of life" seems to be a major motivation for the move to Maine (and Washington County) according to Ploch's survey (reference 44). It appears that these immigrants are willing to give up the higher



paying jobs to find a more relaxed lifestyle. The new comers "Value Maine's Natural resources, its lack of population crowding, and the positive personal attributes of its citizens." High land prices and taxes in the more rapidly growing areas elsewhere have been an incentive to move to Maine as well. Other in-migrants to Maine are older persons, returning to their State or retiring after years of visiting. However, the majority of in-migrants fall between the ages of 12 and 64 years of age, with 51 percent under 35 years of age.

### Housing

The Census reported that in 1970 there was a total of 14,021 housing units in Washington County. Of this total, 9,468 housing units were occupied, 8,010 (84.6%) were occupied by their owner, 1,458 (15.4%) were rented. Two thousand two hundred eighty-four dwelling units (14.7%) were vacant, and 2,269 were seasonal units. Only 386 of the 2,284 vacant units were actually available with 208 for sale and 178 for rent. The rest (1,898) were classified as "other vacant" by the Census, and according to Census definition were units held for settlement of an estate, units held for occupancy by a caretaker, units held for personal reasons by the owner, or year-round units used seasonally.

In 1970, there was a total of 28,989 people living in housing units in Washington County. The average household size, therefore, was 3.1 persons per household (28,989 people divided by 9,468 occupied housing units).

Most of the structures in the county were one family units. Of the 11,752 year-round housing units in Washington County, 10,285 (87.5%) were one unit structures, 639 (5.4%) were structures with two, three, or four units, 123 (1.0%) were structures with 5 to 19 units, and 705 (6.0%) were mobile homes or trailers. The 1970 Census data also showed that housing in Washington County was old with 72.8 percent (8,550) of the year-round houses being built before 1940.

In 1970, the Census relied on two indicators to describe the condition of a housing unit and determine whether or not it was substandard. These two indicators were plumbing facilities and numbers of individuals per room per housing unit. When a unit was described as having more than one person per room or lacking complete plumbing it was considered substandard. Complete plumbing was defined as including three items; piped water, a flush toilet, and a bathtub or shower.

Using these two indicators, the 1970 Census reported that Washington County had a total of 3,583 (30.5% of year-round units) housing units which lacked complete plumbing facilities, and 625 units (6.6% of occupied units) which were over-crowded. Although, the data was not adjusted for double counting, they suggest that perhaps as many as one third of the housing units in Washington County were substandard.

Windshield surveys, interviews with municipal officials, and analysis of tax records were performed in order to update the Census information and present some picture of the housing situation in Washington County in 1975

(reference 45). Compilation of the data showed that Washington County gained 1,617 new housing units and lost 266 over the five year period between 1970 and 1975. This resulted in a net increase of 1,351 housing units or a growth rate of approximately 12.8 percent for the county. The major components of the housing change in the county were new single family dwellings and new mobile homes, together accounting for close to 84 percent of the additions. Of the total of new units, 695 were single family units, 659 mobile homes, 131 multi-family units, and 132 units were converted from other type structures.

The vacancy rate is an indicator of the health of the housing situation. A healthy vacancy rate, usually around 6 percent allows for a certain mobility in the population and provides a choice in housing types and locations. The vacancy rate for Washington County in 1970 as defined by the Census falls short of this at 4.1 percent. Vacancy rates in 1975 for each community as well as the county on the whole were generated by the WCRDC (reference 46) through sales and rental market surveys. Their surveys revealed that of the total number of year-round housing units counted in the windshield survey (11,874), 68 were vacant and for sale, 23 vacant and for rent. This total of 91, expressed as a percent of the total occupied units plus the 91 vacant for sale or rent, indicates a vacancy rate of under one percent. Even with the possibility of having undercounted the vacancy rate is extremely low and indicates a limited housing flexibility of the population.

#### Economic Activity

Most economic activity in the county is related to natural resource-based industries. Few of the resources have been developed beyond their primary state. Generally, the raw resources are exported, bringing more money to the "outsiders" who make them into final products than to county residents. Washington County has an abundance of natural resources, principally, forestry and marine. Over 80 percent of the county's land has commercial value, with 70 percent of it currently being utilized.

Forestry has always been the major industry in Washington County. Forests cover 92 percent of the county's land area. Pulp, paper, and lumber products are the major industrial use of its woodlands. Eleven forest industry companies own approximately 66 percent of the total forest land in the county and provide many jobs. The two largest employers, the St. Regis Company and the Georgia-Pacific, together employ more than 900 county residents; the other companies employ considerably less.

In the fishing industry, shellfish bring in the greatest landed value. Many species of finfish are either ignored or underutilized due to lack of capital to finance harvesting and processing. Although the county has approximately 700 miles of coastline, the potential for a major fishing industry is limited since federal support of this industry has traditionally been weak and commercial fish are decreasing in number. The county provided nearly 40 percent of the State's softshell clams. Development along the coast, however, has caused some serious pollution problems resulting in the close of nearly 10 percent of the county's clamflats.

Lowbrush blueberries are the backbone of agriculture in Washington County. Growing on the barrens and on former cropland, blueberries from Washington County make up 80 percent of the total blueberry crop for the State. This industry, although seasonal and low skilled, provides jobs and brings millions of dollars a year into the county.

Washington County has a great deal to offer in beauty and history that has attracted people for decades, making tourism an important industry. Tourism, however has not been developed fully because because of the county's remote location.

Washington County has experienced little industrial growth. What growth has occurred has been on the small commercial scale, including new stores, motels, shops, and offices. Some Government jobs have opened up along with some other jobs in the non-manufacturing field. The county has been experiencing a gradual conversion from a blue-collar worker county with jobs primarily in the manufacturing field to a more non-manufacturing county.

A major industrial project, however, has been proposed that could be of economic importance to the county. The Pittston Oil Company is studying the possibility of establishing a refinery and deep water port at Shackford Head in Eastport (reference 41).

#### Employment

Manufacturing, services, and wholesale and retail trade are the three major employment sectors in Washington County. The U.S. Census indicated that 9,490 persons were employed in the county in 1970 with 31 percent in manufacturing, 19 percent in services, 17 percent in wholesale and retail trade, 11 percent in agriculture/forestry/fisheries, 8 percent in construction and mining, 7 percent in public administration, 5 percent in transportation/communications/utilities and 3 percent in finance, insurance, and real estate sectors. Table 4 shows a total workforce decrease of 6 percent and the shift in employment distribution since 1950.

TABLE 4

Employment by Industry  
Washington County, Maine

<u>Industry</u>	<u>1950</u>	<u>Percent of Employed</u>	<u>1960</u>	<u>Percent of Employed</u>	<u>1970</u>	<u>Percent of Employed</u>	<u>Percent change 1950-1970</u>
Agriculture, Forestry Fisheries	1959	19.3	898	9.4	1,016	10.7	-48.1
Construction and Mining	638	6.3	1,256	13.2	749	7.9	16.9
Manufacturing	3,265	32.2	3,047	31.9	2,960	31.2	-9.3
Transportation, Communication, Utilities	694	6.8	513	5.4	445	4.7	-35.9
Wholesale and Retail Trade	1,348	13.3	1,488	15.6	1,587	16.7	17.7
Finance, Insurance, and Real Estate	92	0.9	110	1.2	235	2.5	155.4
Services	1,523	15.0	1,474	15.4	1,827	19.3	20.0
Public Administration	446	4.4	511	5.4	661	7.0	48.2
Other	169	1.7	247	2.6	—	—	—
Total	10,134		9,542		9,490		-6.4

Notes: 1970 figures to not include 14 and 15 year olds. Total employment including those would equal 146; 46 in agriculture, 100 nonagriculture.

Source: U.S. Census, 1950, 1960, 1970

Although employment in manufacturing decreased between 1950 and 1970 the manufacturing sector employed the largest proportion of the labor force throughout that period. The decreased employment in this sector was due largely to the decline of the sardine canning industry. The agriculture/forestry/fisheries sector went from second place in 1950, employing 19.3 percent of the labor force, to fourth place in 1970, employing 10.7 percent. The decline in this sector reflects the overall decline in fish resources off the Northeast Atlantic coast and the decrease in the number of acres farmed. Employment in the services sector increased between 1950 and 1960, and 1960 and 1970 to employ the second largest proportion of the labor force, 19.3 percent in 1970. Employment in the wholesale and retail trade sectors has increased each decade between 1950 and 1970 (with 16.7 percent employed) and follows the services sector.

In 1970, half of those employed in the county were blue collar workers, an unusually large proportion of whom were nonfarm laborers, almost 13 percent versus 6 percent for the State. Seventeen percent were classified as craftsmen, foremen and kindred workers versus 15 percent for the State and fewer than 9 percent were considered professional versus 12 percent for the State (Table 5).

TABLE 5

OCCUPATIONAL CATEGORIES: WASHINGTON COUNTY AND MAINE

<u>Occupation</u>	<u>Washington County</u>		<u>Maine</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
Professional, technical & kindred	803	8.5	44,924	12.3
Managers/Administrators, Exfarm	794	8.4	32,234	8.8
Sales Workers	478	5.0	21,005	5.7
Clerical & Kindred Workers	1,072	11.3	50,611	13.8
Craftsmen, and Kindred Workers	1,600	16.8	55,148	15.1
Operatives, except transport	1,567	16.5	68,978	18.9
Transport Equipment Operatives	471	5.0	15,085	4.1
Laborers, except farm	1,203	12.7	22,195	6.1
Farmers and farm managers	172	1.8	4,806	1.3
Farm laborers & farm foremen	244	2.6	5,340	1.5
Services, ex private household	920	9.7	39,875	10.9
Private household workers	166	1.7	5,649	1.5
Total All Workers	9,490	100.0	365,850	100.0

Source: U.S. Bureau of the Census, 1970 Census of Population, "General Social and Economic Characteristics."

Historically, the shortage of year-round jobs has made for high unemployment in Washington County and has been a significant factor in making this county close to the poorest in Maine. Unemployment rates ranged from 8.6 to 9.6 percent in the 1970 to 1974 period, averaging 13 percent in 1975.

The seasonal nature of available employment puts personal income at a very low level. 1970 Census figures show that income of Washington County residents were among the lowest in the State. The median income recorded by the Census for 1969 was \$6,137 for Washington County, the lowest in the State whose median income level was \$8,205. Close to 30 percent of all families in Washington County had incomes under \$4,000 with about 7 percent earning more than \$15,000. This compares to the State figures of 15.7 percent earning less than \$4,000 and 11.2 percent earning more than \$15,000. The median figure of the various sources of income of Washington County residents is presented in Table 6, along with the percentage of families who receive each type. Data for the State is also provided for comparison.

Table 6  
Median Incomes

<u>Sources of Income</u>	<u>Washington County</u>		<u>State of Maine</u>	
	<u>\$</u>	<u>Percent of Families</u>	<u>\$</u>	<u>Percent of Families</u>
Mean wage or salary	\$6,489	78.5	\$8,314	86.5
Mean nonfarm self-emp	4,990	19.9	6,526	12.1
Mean farm self-emp	2,832	3.3	2,939	2.8
Mean social security	1,423	27.9	1,597	22.0
Mean public assistance or public welfare	1,198	8.9	1,189	5.4
Mean other	1,431	25.3	1,829	31.0

#### Land Use

Washington County's surface area totals 1,865,600 acres or 2,915 square miles. The total land area for the county equals 2,554 square miles. The major land use categories as identified by the WCRPC Land Use Element of the Regional Comprehensive Plan for Washington County are: forest industry land, privately-owned forest land, agriculture, Federal and State lands, Indian reservations, and other. Table 7 provides a breakdown of these categories by acreage and percent of total land area.

Table 7  
Land Use, Washington County, 1975

<u>Category</u>	<u>Acres</u>	<u>Percent of Total</u>
Forest Industry Land	1,055,824	64.6
Privately-Owned Forest Land	336,576	20.6
Agriculture	69,500	4.2
Federal and State Lands	59,600	3.6
Indian Reservation	18,100	1.1
Other	94,900	5.9
Total Land Area	1,634,500	100.0



Lands commercially forested in Washington County total approximately 1,439,000 acres. This includes forest industry land, privately-owned forest land, and some public lands. This acreage totals 89 percent of the total land area in the county.

Approximately 66 percent of the total land area of Washington County is being managed for pulpwood and lumber production by 11 companies with a minimum of 1,900 acres per owner. Historically this land has been kept off the private real estate market, and if sold, it usually goes to another forestry concern.

Most urban development in Washington County has occurred within the coastal communities which contain approximately 75 percent of the county's total population. The county has over 700 miles of coastline with very little development in comparison to other coastal counties in Maine.

The "other" category includes urban, residential, transportation, institutional, industrial, commercial uses, making up 5.9 percent of Washington County's land area. For the most part, coastal development in the county reflects the maritime and fishing economies of the last century. About a dozen small communities are scattered along the shoreline at the mouths of rivers where inlets offer protection for sailing vessels. Most of these towns are smaller today than they were in 1900.

During the first half of this century, coastal development was minor. A few towns installed sewer systems; wharves and breakwaters were built on a small scale and some dredging and filling operations were conducted. In general, however, industry and urbanization had a minor impact during this period.

Since about 1960, the county's coastal resources, including open land, have experienced increasing pressure for development. Specifically, residences and seasonal homes have been built in unprecedented number along the shore. Parcels of land which were formerly of minimal value for want of access are in great demand for vacation retreats. Rising family income levels and more leisure time have brought about a noticeable increase in home development in the county.

Agriculture in Washington County developed in a subsistence level when early settlers first went up the Machias River in search of hay in 1762. Small family farms flourished from 1800 to 1880 and have since declined. Today, only a small portion (4.2%) of Washington County's total land area is used for agricultural production. Lowbrush blueberries are the backbone of agriculture in Washington County as discussed earlier. As new techniques for propagation, fertilization, and increased production are developed and applied, the blueberry crop will become increasingly valuable to Washington County's economy. In addition there are smaller amounts of land devoted to poultry, vegetable, dairy and beef cattle farming.

A number of factors contribute to the limited extent of agricultural activities within the county. Some soils are unsuitable and the growing season is short. Transportation time, distances, processing facilities, and costs are also factors that limit expansion of agricultural activities in Washington County.

The county ranks second in the State in the amount of inland surface water, being exceeded only by Piscataquis County. Within the confines of the county are 277 lakes and ponds totalling 134,053 acres. There are more than 1,000 miles of rivers and streams, covering a total 5,522 acres, in the county with the majority being among the cleanest in the State because of lack of intensive industrial, agricultural, or residential development within the watersheds. Wetlands are an important and fragile resource in the county, serving to limit flood damage, augment water flows during dry periods, and preserving wildlife habitats. The Department of Inland Fisheries and Wildlife estimates that 91,525 acres of Washington County fall within some category of wetlands. These inland water resources total 231,100 acres taking up 12.4 percent of the county's total area.

Many lakes in the county are relatively unchanged by man, and accessible only by foot. The rapid development of permanent logging roads had increased accessibility of some lakes and ponds by automobile, extending their recreational use.

As indicated in the land use table, close to 60,000 acres or 4 percent of Washington County's land area is classified as Federal and State lands. A recent exchange of public lands, held in the form of public lots, to the Georgia-Pacific Paper Company has reduced the total acreage of public lands in Washington County by close to 10,000 acres. The exchange resulted in an increase of public lands in a county in the eastern part of the State bordering the Bigelow preserve.

Approximately 25,000 acres are under Federal jurisdiction. The Bureau of Sports Fisheries and Wildlife manages the majority of this land within the Moosehorn National Wildlife Refuge which covers an area of 22,666 acres. Moosehorn provides a visitor center, a nature auto tour, and hiking trails, as well as other facilities. Two thousand eight hundred acres of this refuge are designated as a Federal wilderness area. The remaining Federal lands include the St. Croix Island National Monument, property on Petit Manan Point and Island, and some military holdings.

The Bureau of Parks and Recreation and the Department of Inland Fisheries and Wildlife manage much of the land under State jurisdiction.

The Pleasant Point Indian Reservation is located in Perry and accounts for the 18,100 acres or 1.1 percent of Washington County's land area.

## Recreation

The most popular outdoor recreation activities in the State of Maine, according to the 1977 Maine Statewide Comprehensive Outdoor Recreation Plan (SCORP), are picnicking, swimming, bicycling, snowmobiling and nature walking. Only summer and winter activities were surveyed, however, so hunting, which is basically a fall activity, was not listed, although it is a very popular past-time in Maine. Driving for pleasure (sightseeing in general) was not studied, but if it were, it would probably be the most popular summer activity. Other popular activities include motorboating, camping, fishing, canoeing, ice skating, jogging, basketball, ice fishing, tennis, downhill and cross country skiing.

Washington County has a relatively low population estimated at about 35,000 people which has been gradually increasing over the past 10 years. Recreation facilities in the county are also relatively few and are used to a great degree by tourists passing through the area on their way to Canada. The following are the major recreation areas in the Washington County/Cobscook region:

Cobscook Bay State Park, Edmunds (868 acres), offers overnight camping, nature trails, picnicking, fishing, boat launching, and snowmobiling;

Quoddy Head State Park, Lubec (531 acres) is the eastern most point in the U.S. as well as having the greatest tidal range, and offers picnicking, a nature trail, and sightseeing;

Roque Bluffs State Park, Roque Bluffs (274 acres) is being developed as an overnight camping area and offers picnicking, swimming, and fishing;

Gleason Point, Perry (100+ acres) is undeveloped but has high potential either as a day use or overnight camping area;

Eastern Head, Trescott (263 acres) is undeveloped but includes nearly 16,000 feet of ocean frontage and a 500 foot beach within a protected harbor;

Fort O'Brien, Machiasport, (2 acres) is an historic site maintained as a day-use facility;

St. Croix Island National Monument, Calais (14 acres) is an undeveloped historical landmark with future plans calling for the development of historical interpretation facilities;

Moosehorn National Wildlife Refuge, Edmunds and Baring (22,666 acres) provides a visitor center, nature auto tour, hiking trails, and other facilities;

Great Works Wildlife Management Area, Edmunds (641 acres) is managed primarily as a waterfowl nesting area, but is well suited for hunting, fishing, canoeing, hiking, wildlife photography, and camping;

National Geographic Society Boulder, Perry, marks the 45th parallel, half way between the North Pole and the Equator;

Roosevelt Memorial Park, Campobello Island, New Brunswick, Canada is a nearby tourist attraction which includes President Franklin D. Roosevelt's summer home, a museum and related facilities.

In addition to the preceding recreation areas, there are several boat access facilities in Washington County located in Robbinston, Jonesport, Lubec, Millbridge, Vanceboro and Danforth. There are also a number of buildings and sites on the National Register of Historic Places located in Washington County, including five in Eastport and two in Lubec. Other public outdoor recreation facilities in the county include six public parks, tennis courts in Eastport, Machias and Calais, a golf course and swimming pool in Calais, and several private camping areas along with local docks and beaches.

There are relatively few public recreation and support facilities available in the Cobscook Bay area compared to other regions in the State of Maine. There are no major commercial centers, mostly seasonal motels (with none in Eastport), and only one seasonal diner and no indoor recreation facilities in Eastport. The current most popular resident recreation activities in this area are hunting and fishing.

#### Historic and Archeological Resources

The earliest known prehistoric sites in the Passamaquoddy Bay area date from about 1000 B.C. to the time of European contact. Other sites dating from as early as 9000 B.C. may have existed within the region, but rising sea levels and attendant erosion may have destroyed or obscured their remains. Also, it should be noted that most recorded sites were identified by presence of large shell heaps, which may not have been a feature of earlier sites.

Recorded prehistoric sites in Cobscook Bay reflect intensive use of marine food sources, primarily soft shell clams. Some hunting also appears to have been done. Most tools recovered consist of projectile points of stone, and scraping and cutting implements of stone or made from beaver incisors. Pottery appears in the area at the beginning of this period (c. 1000 B.C.), but seems later to have decreased in use.

Evidence of semi-subterranean oval or round dwellings about 12 ft. in diameter are present at the sites dating between 200 and 800 years ago. Finds of animals killed in winter demonstrates that the occupants of these houses lived on the coast during that season.

Toward the end of the prehistoric period there are indications of a worsening of climate, and deer population appears to have dropped considerably. Rising sea levels in the region also changed the locations of productive clam beds. A shift to seasonal migration of people from the coast to inland areas may have been partly conditioned by these environmental changes.

At the time of European contact, the native inhabitants appear to have spent their summers on the coast and wintered inland. The reverse of the prehistoric pattern, this probably reflects adaptation to the European fur trade system, with trapping in the interior during winter and trade with the ships which arrive in summer.

Recorded prehistoric sites within Cobscook Bay occur primarily on relatively sheltered portions of the shoreline, often near estuaries. Since archaeological surveys of the region is still incomplete, an archaeological reconnaissance of these area may become necessary as project planning proceeds to further stages of the study.

Historic period land use of the Cobscook Bay coastline has been largely maritime in nature, though there have been repeated attempts since the early 19th century to mine various metallic ores at exposed cliff faces.

The numerous coves and inlets of Cobscook Bay provided secluded rendezvous for smugglers between the French and New England colonies during the 17th and 18th century, and British Canada and New England during the Revolutionary War and the War of 1812 periods. Fishermen also used the bay from an early date and their activity became a mainstay of the area's economy during the 19th century. The considerable tidal fluctuation and narrow channels of Cobscook Bay probably resulted in numerous wrecks.

#### Electric Energy Situation

##### System

The availability of dependable, economical supply of electricity is of vital importance to the people of New England and to the economy of the region. An important instrument in providing this electric service is the New England Power Pool (NEPOOL), a regional organization established in 1971 by the area's utilities to further enhance the reliability and improve the economics of bulk power supply. The electric systems making up NEPOOL own or control 99.6% of all New England generation.

NEPOOL has two main functions, one planning and the other operations. The primary function of New England Power Planning (NEDPLAN) is to provide a central planning staff which has the responsibility of preparing electric load forecasts, evaluating alternate generation and transmission plants, recommending reliability standards, and facilitating the joint ownership of power plants through optimization of size and location.

The operating arm of NEPOOL is the New England Power Exchange (NEPEX). Utilizing advanced computers and a complex communications network, NEPEX, through its four satellites, located in Connecticut, Massachusetts, New Hampshire and Maine, controls all the major generating units in New England, insuring that at all times power is produced from the most efficient units available and at the lowest possible cost, consistent with maximum reliability of service.

Greater reliability is a fundamental objective and benefit of power pooling. This benefit is most readily explained in terms of an emergency. Assume, for example, that one of the interconnected companies suddenly loses the output of a major generating unit. Instantly, other companies make up the temporary deficit. Energy is constantly interchanged among member companies with no awareness by the customer of its source.

Further reliability benefits of NEPOOL arise from the coordinated scheduling of shutdowns for maintenance and repair of generating units and transmission activities. Operation of the pool allows coordination of this "downtime" so that service reliability to customers of all companies is not threatened by the coincidental unavailability of bulk power facilities.

Consumers do not demand electric energy in the same quantity throughout the year or even through the day. The amount of electricity being demanded by customer in one peak use hour of the day could be two times the lowest hourly use during that day. But electric suppliers must have enough power production capacity to meet that one peak hour demand.

At the same time, generating units cannot operate all year long. They require regular maintenance. Because many of them operate under extreme conditions of temperature and steam pressures, they are subject to unexpected outages. So the utility must not only have enough capacity for that peak hour use, but it must have "reserve capacity" as well. If each company operated by itself, its "reserve capacity" might have to be a larger portion of its forecasted peak demand depending on the number and size of generating units it had. With the diversity afforded by NEPOOL, all utilities in the pool can assure reliable service, with an adequate reserve, at a substantial savings to customers.

Because of the pool's operations, a lesser number of generating units can be built than if each company was only building plants for its own customers and this economy of scale provides further savings to consumers.

Another economic benefit comes in the operation of power plants. The actual operating costs of producing electricity vary widely from one power plant to another depends on its age, design, type and delivered cost of its fuel. Through its computer capabilities, NEPOOL optimizes the operation of the combination of generating units which results in lower costs consistent with maximum reliability of service, without regard to which company actually owns the unit.

It is evident that the existance of NEPOOL results in lower energy costs and increased energy security and reliability for New England. NEPOOL also makes it possible for intermittant energy sources such as run of river hydropower or tidal power to be intergraded into a system so as to allow maximum use of the resources.

NEPOOL's members include investor owned companies, municipalities and cooperatives. The total supply of electric energy in New England is broken down by ownership in Table 8.

Table 8

Source of New England Electric Supply Percent of Total	
Source	Percent of Total
Investor Owned Utilities	91
Municipal and Cooperative	1
Non-Utilities	5
Imports	3

In New England, there are 38 class A and class B investor owned utilities (that is, having annual operating revenues in excess of one million dollars). Table 9 lists these utilities and figure 7 shows the location of New England largest electric utility groups.

#### Demand

The demand for electricity fluctuates during the course of the day. The peak demand is about twice the demand required by customers during the early morning hours.

Figure 8 depicts hourly demand patterns for peak winter and summer days and for typical spring and autumn days. Currently and historically New England experiences winter peaks. In 1979, a peak demand of about 15,000 megawatts was experienced on 19 December. Average daily peaks are around 12,000 MW and typically during early morning hours demand is around 7,000 MW.

Because people's habits tend to be similar, however, this rise and fall in demand is predictable. The selection of the type of plant to meet customer demand is based on the type of load a plant must operate almost constantly to handle the continuous day and night demand (base load). A second type of plant handles the heavy and fluctuating daytime demand of homes, schools, offices, and industry (intermediate load). These plants are called "cyclers" and can be operated in a manner that allows them to

# Investor-Owned Class A and B Electric Utilities in New England

December 31, 1978

(System ownership shown in parenthesis)

## Maine

Bangor Hydro-Electric Company  
Central Maine Power Company  
Maine Electric Power Company, Inc.†  
Maine Public Service Company  
Maine Yankee Atomic Power Company\*

## New Hampshire

Concord Electric Company  
Connecticut Valley Electric Company, Inc. (CVPS)  
Exeter and Hampton Electric Company  
Granite State Electric Company (NEES)  
Public Service Company of New Hampshire

## Vermont

Central Vermont Public Service Corporation  
Citizens Utilities Company—Newport Division  
Green Mountain Power Corporation  
Vermont Electric Power Company, Inc.†  
Vermont Yankee Nuclear Power Corporation\*

## Massachusetts

Boston Edison Company  
Brockton Edison Company (EUA)  
Cambridge Electric Light Company (NEGEA)  
Canal Electric Company (NEGEA)  
Fall River Electric Light Company (EUA)  
Fitchburg Gas and Electric Light Company  
Holyoke Power and Electric Company (NU)  
Holyoke Water Power Company (NU)  
Massachusetts Electric Company (NEES)  
Montaup Electric Company (EUA)  
Nantucket Electric Company  
New Bedford Gas and Edison Light Company (NEGEA)  
New England Power Company (NEES)  
Western Massachusetts Electric Company (NU)  
Yankee Atomic Electric Company\*

## Rhode Island

Blackstone Valley Electric Company (EUA)  
Narragansett Electric Company, The (NEES)  
Newport Electric Corporation

## Connecticut

Connecticut Light and Power Company, The (NU)  
Connecticut Yankee Atomic Power Company\*  
Hartford Electric Light Company, The (NU)  
Northeast Nuclear Energy Company (NU)  
United Illuminating Company, The

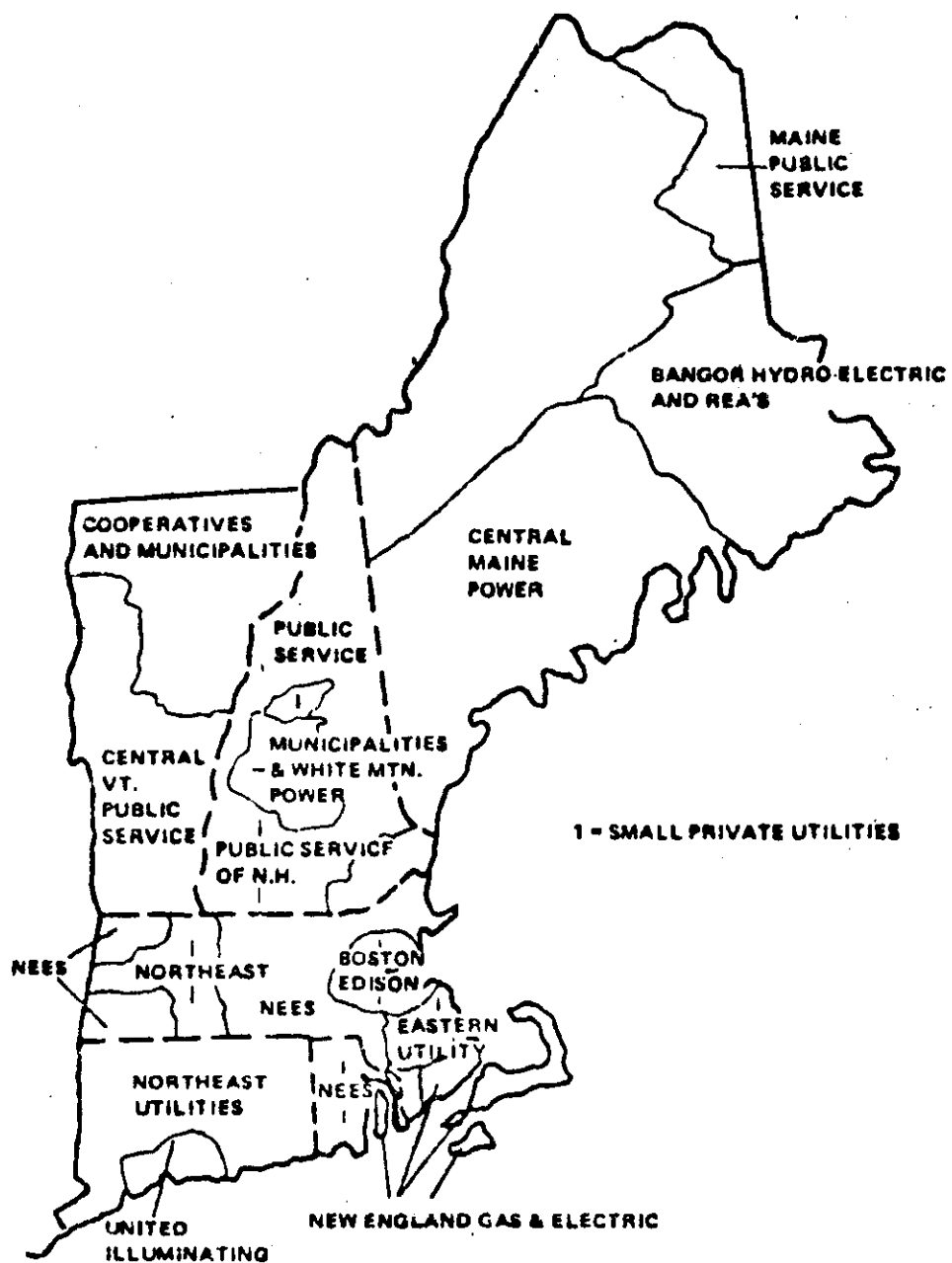
## System Abbreviations:

CVPS — Central Vermont Public Service Corporation  
EUA — Eastern Utilities Associates  
NEES — New England Electric System  
NEGEA — New England Gas and Electric Association  
NU — Northeast Utilities

† — Jointly-owned transmission company

\* — Jointly-owned nuclear generating company

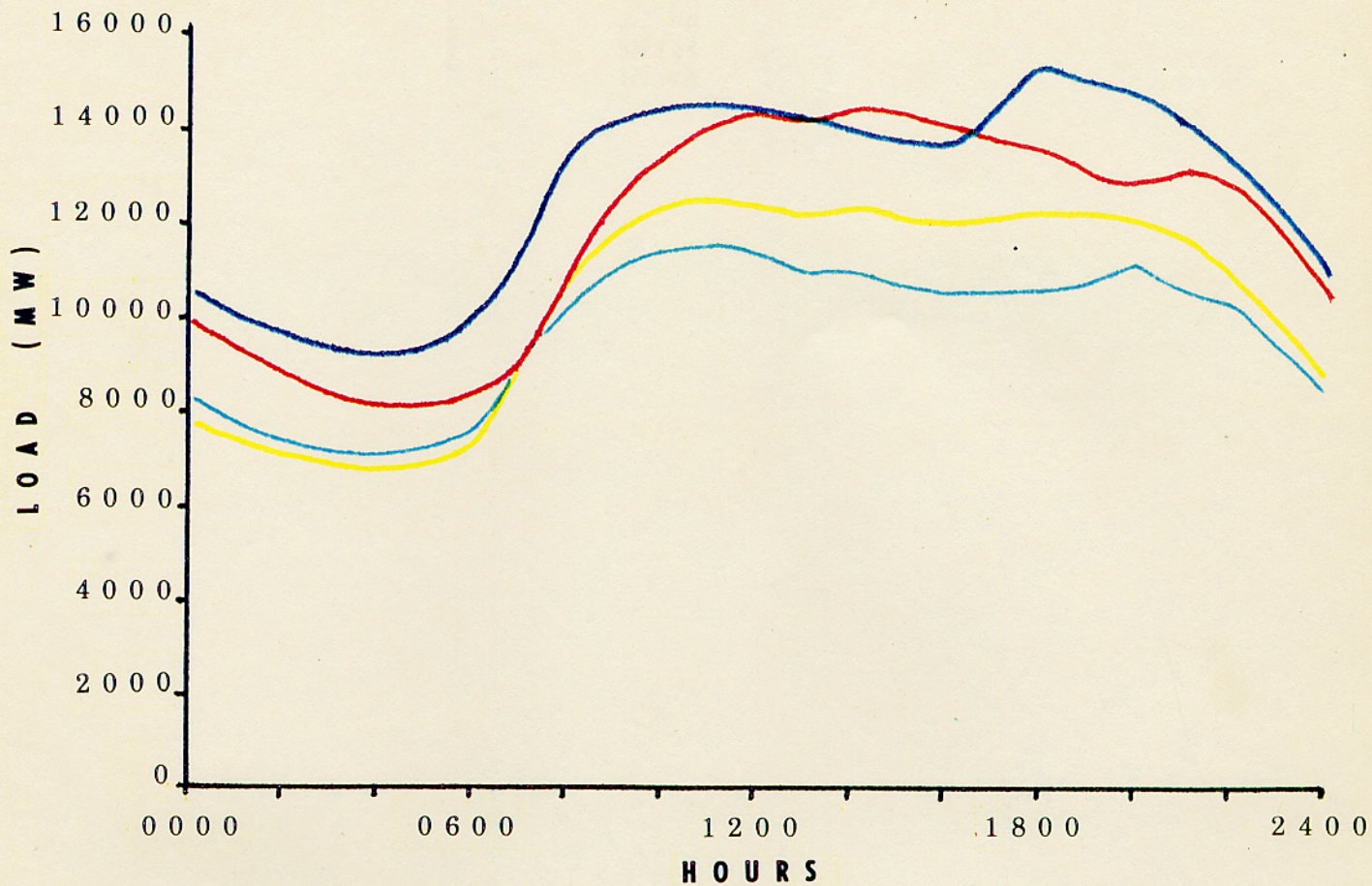




Source: A study of the Electric Power Situation in New England 1970-1990, New England Regional Commission.



# DEMAND CURVES FOR NEW ENGLAND



WINTER PEAK LOAD 12/19/79

SUMMER PEAK LOAD 8/2/79

TYPICAL SPRING WEEKDAY 4/18/79

TYPICAL AUTUMN WEEKDAY 10/10/79

TIDAL POWER STUDY  
COBSCOOK BAY, MAINE

TYPICAL DEMAND CURVES  
FOR NEW ENGLAND

August 1980

U.S. Army Engineer Division  
New England  
FIGURE 8



shutdown and startup each day. A third type of plant, called peaking plants, handle the rapid upsurges of peak demand such as those between 5 and 6 pm in the winter and mid-afternoon in the summer. It is uneconomical, on any basis, for one kind of plant to handle the entire electric energy demand. A mixture of types is necessary.

A nuclear plant is more expensive to build, but less expensive to operate, making it an ideal choice as a base load plant. Today the total cost of a kilowatthour from an existing nuclear plant in New England is less than just the fuel cost component of fossil-fueled power plants. Its round-the-clock operation supplies continuous power for the constant portion of consumer requirements. It is also a natural partner for pumped-storage generation because of its low fuel cost. A pumped-storage plant uses low-cost, off-peak electric power to pump water into an upper reservoir during periods of low consumer use. The water is then released during periods of high demand to generate electricity. This form of operation provides peak serving energy at a lower cost than peak energy production by oil-fired alternatives.

Electric energy generated in hydroelectric plants nuclear-fueled reactors, coal or oil-fired plants and diesels or combustion turbines are the most common. They all require conventional energy sources which turn an electric generator, either directly, as in the case of water power, or indirectly using heat energy to produce steam to turn a turbine as with coal-fired, oil-fired plants and nuclear reactors.

In 1978, nuclear plants provided 35 percent of New England's generation. Despite increasing reliance on nuclear generation, fossil-fueled steam plants continues to supply the largest part of New England's energy requirements.

Table 10 shows sources of New England's generating capacity at the end of 1978.

Table 10

Generation Sources in New England

<u>Source</u>	<u>Megawatts</u>	<u>Percent</u>	<u>Present Use</u>
Hydro	2,691	12.9	Peaking/Base
Nuclear Steam	4,407	21.2	Base
Fossil Steam	12,114	58.2	Base/Intermediate
Gas Turbine	1,303	6.3	Peaking
Internal Combustion	302	1.4	Intermediate/Peaking

Table 11 shows types of fuel (by percent) for New England's generation in recent years compared to U.S. average.

Table 11

Fuel Sources for Electric Power  
United States and New England  
(Percent of Total)

Fuel Type	1972		1974		1976	
	U.S.	N.E.	U.S.	N.E.	U.S.	N.E.
Gas	21.5	1.0	17.2	1.2	14.7	4.0
Coal	44.2	4.7	44.5	7.4	46.3	2.6
Hydro	15.6	7.5	16.1	6.9	13.9	6.9
Nuclear	3.1	14.0	6.1	24.4	9.4	33.2
Oil	15.6	72.8	16.1	60.1	15.7	56.9

Inspection of Table 11 reveals that fuel consumption for electric energy production in New England is radically different than it is elsewhere in the United States. While coal dominates most of U.S. production, oil is the primary fuel used in New England, followed closely by nuclear. This unusual fuel mix results primarily from the fact that New England has to date discovered no significant conventional energy resources of its own (other than wood and water) which can be utilized in central generating stations. It must rely on other regions and other countries for its coal, oil, gas and uranium. For fossil fuels, this requires transportation of large quantities into the region. A one million kilowatt electric plant would require the daily delivery of 10,000 tons of coal (a one-mile long train), 1.7 million gallons of oil per day or 250,000 mcf of gas per day. By comparison, the equivalent amount of fuel for a nuclear plant can be delivered by six tractor trailer trucks - just once per year.

The cost of fuel represents 55 percent of electric operating expenses and it is the largest single expense item for the industry in the region. The fuel consumed in 1978 by the total electric utility industry in New England was equivalent to about 5.3 billion gallons of oil.

At present, continued development of nuclear power offers the greatest promise for controlling New England's fuel cost as well as providing protection against dwindling suppliers, market uncertainties and environmental restrictions associated with fossil fuels.

Maine would be the primary area impacted by a potential tidal power project. While it is not known how much energy a tidal power project would supply for Maine it is reasonable to assume that a large percent of such a project's energy would be used in Maine.

In 1978 Maine consumed 7,699 gigawatt hours (GWH) of energy (a gigawatt hour is equivalent to one million kilowatt hours). Maine generated 8,208 GWH, therefore, Maine was a net exporter of energy. In fact in the same time frame New England was an exporter of energy generating 79,737 GWH and using only 75,289 GWH. However, of the total generation, over 40,000

GWH (950 GWH in Maine) was generated using oil and over 28,000 GWH (5,000 in Maine) using nuclear power. Table 12 lists Maine's generating facilities and the map shown as figure 9 shows the location of these facilities.

Electricity is carried from generating plants to load centers by means of high-voltage transmission lines, and then is carried to individual customers through low-voltage distribution lines. Throughout New England, additions and improvements to the transmission and distribution systems are constantly being made to interconnect sources of energy supply, to strengthen ties with neighboring utilities and to supply customers' increased requirements for power.

The region's major generating plans are interconnected by 345,000 volt transmission lines which now extend from New York State through Connecticut and Massachusetts to New Brunswick, Canada. Underlying the 345 kv "backbone" transmission system are lower voltage (69,000, 115,000 and 230,000 volts) transmission lines which generally serve local as opposed to regional power requirements by transmitting power from the "backbone" system to local load centers.

These lines, which are shown on figure 10 are part of the transmission grid which extends over the entire northeast region of the country. This grid improves the reliability and economy of the New England power supply by making it possible to transfer power from one area to another to meet constantly changing needs while always using the most efficient generating units available.

#### Future Condition Without the Project

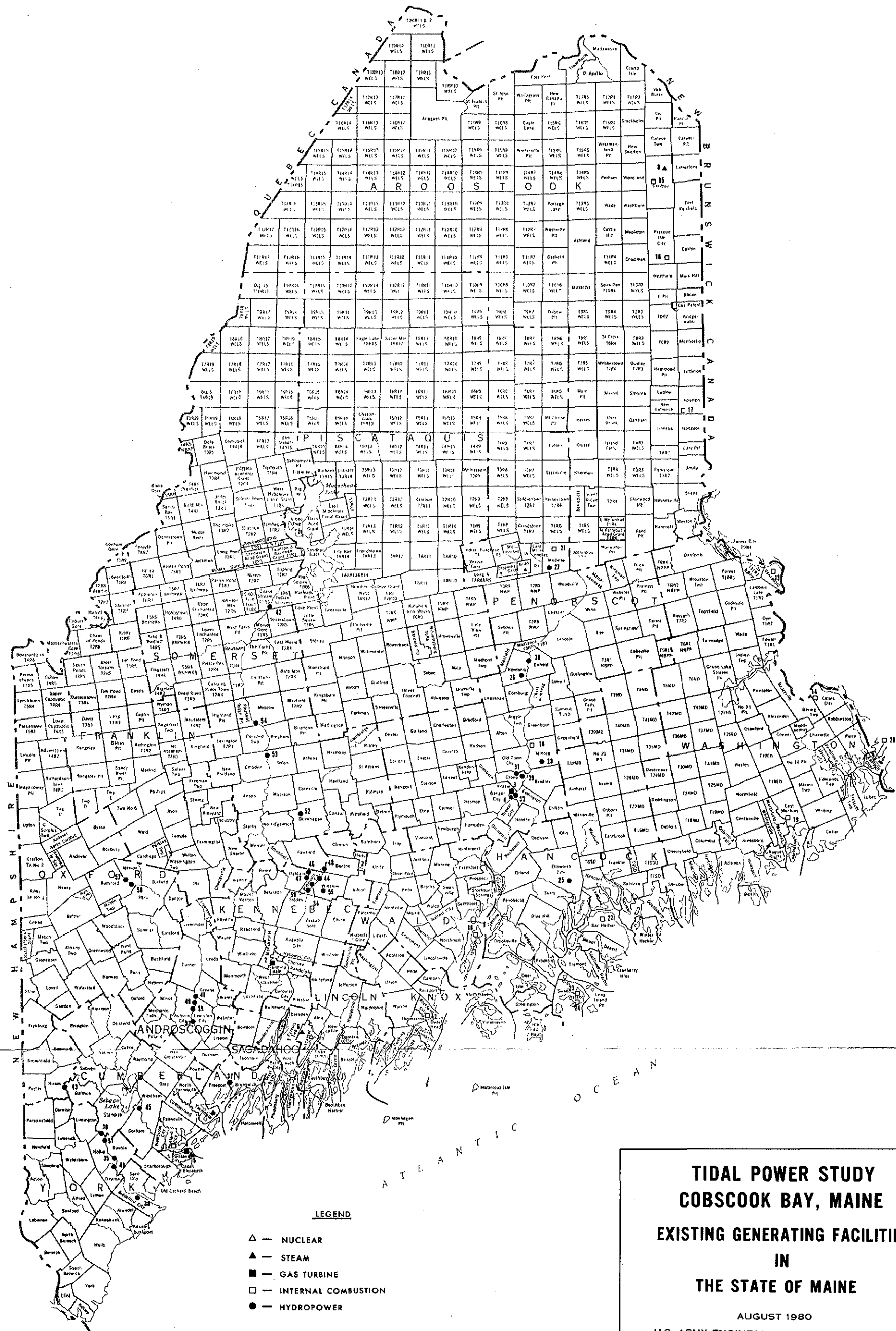
##### Physical Setting

The physical setting of this bay will remain essentially unchanged. Water quality should remain stable unless other possible projects are undertaken. With or without a Federal tidal power project some changes will occur in the area if either the Pittston Oil Refinery or the Half Moon Cove Tidal Power project are developed.

##### Environmental Setting

The state of the aquatic ecosystem within the project area can be assumed to follow the same pattern as it has in the past and now exists. Also, conditions would be, in part, dependent upon the socio-economic conditions in the area.

Mariculture would most likely continue to be developed in the Cobscook Bay area, with the success of these developments depending on market conditions, sophistication of culturing techniques, and availability of sites.



# EXISTING GENERATING FACILITIES

Project Number	Project Name	Community	*Capacity (KW)		Type of Unit
			FPC (1976-1978)	DOE (1979)	
1	Cape	S. Portland	35,000	34,000	Gas Turbine
2	Farmingdale	Farmingdale	4,000	4,000	Gas Turbine
3	Graham	Veazie	6,000	6,000	Gas Turbine
4	Graham Station	Veazie	57,500	58,000	Steam
5	Cape	S. Portland	22,500	24,000	Steam
6	Mason	Wiscasset	146,500	139,000	Steam
7	W. F. Wyman	Yarmouth	587,000	514,000	Steam
8	Caribou Steam	Caribou	19,000	19,000	Steam
9	*Maine Yankee	Wiscasset	830,000	864,000	Steam (Nuclear)
10	Islesboro	Islesboro	254	1,000	Internal Combustion
11	Peaks Island	Portland	1,756	3,000	Internal Combustion
12	Rockland	Rockland	2,000	2,000	Internal Combustion
13	Portable Plant	Vanceboro	300	1,000	Internal Combustion
14	River Street Plant	Calais	2,200	5,000	Internal Combustion
15	Caribou	Caribou	8,100	7,800	Internal Combustion
16	Flos Inn Diesel	Presque Isle	6,000	6,000	Internal Combustion
17	Houlton	Houlton	1,000	1,000	Internal Combustion
18	Milford	Milford	2,000		Internal Combustion
19	E. Machais	E. Machais	1,000		Internal Combustion
20	Eastport	Eastport	4,000		Internal Combustion
21	Medway	Medway	8,000		Internal Combustion
22	Bar Harbor	Bar Harbor	8,000		Internal Combustion
23	Swan Falls	Swans Island		3,000	Internal Combustion
24	Minturn	Minturn		3,000	Internal Combustion
25	Ellsworth Falls	Ellsworth	8,975	9,000	Hydro
26	Howland	Howland	1,875	3,000	Hydro
27	Medway	Medway	3,440	5,000	Hydro
28	Milford	Milford	6,400	8,000	Hydro
29	Orono	Orono	2,332	4,000	Hydro
30	Stanford	Enfield	3,800	3,000	Hydro
31	Stillwater	Old Town	1,975	4,000	Hydro
32	Veazie	Veazie	8,400		Hydro
33	Androscoggin 3	Lewiston	3,600	3,600	Hydro
34	Messalonskee 4	Waterville	800	1,000	Hydro
35	Bar Mills	Hollis	4,000	5,000	Hydro
36	Bonny Eagle	Standish	7,200	6,000	Hydro
37	Brunswick	Brunswick	1,473		Hydro
38	Catarack	Biddeford	6,650	7,000	Hydro
39	Continental Mills	Lewiston	1,776		Hydro
40	Deer Rips	Auburn	6,540	6,000	Hydro
41	Gulf Island	Lewiston	19,200	18,000	Hydro
42	Harris	Indian Stream	76,400	76,000	Hydro
43	Hiram Falls	Baldwin	2,400	2,000	Hydro
44	Milstar	Waterville	4,800	5,000	Hydro
45	Gorham Dam #5	Gorham/Windham	2,250	2,000	Hydro
46	Messalonskee #2	Oakland	2,800	3,000	Hydro
47	Messalonskee #3	Oakland	1,600	2,000	Hydro
48	Shawmut	Fairfield	4,650	6,000	Hydro
49	Skelton	Dayton	16,800	16,000	Hydro
50	Messalonskee #5	Waterville	3,900		Hydro
51	West Buxton	Buxton	6,625	7,000	Hydro
52	Weston	Skowhegan	12,000	12,000	Hydro
53	Williams (Solon)	Emden	13,000	13,000	Hydro
54	Wyman Hydro	Moscow	72,000	72,000	Hydro
55	Sebasticook #4	Winslow	1,500	2,000	Hydro
56	Rumford Lower	Rumford	12,800		Hydro
57	Rumford Upper	Rumford	25,000		Hydro

\*FPC (1976-1978) - Principal Electric Facilities, Northeastern Region, Federal Power Commission - 1976;  
Federal Power Commission's Form - 12 Utility operating reports - 1978

DOE (1979) - Inventory of Power Plants in the United States, April 1979; by the U.S. Department of Energy

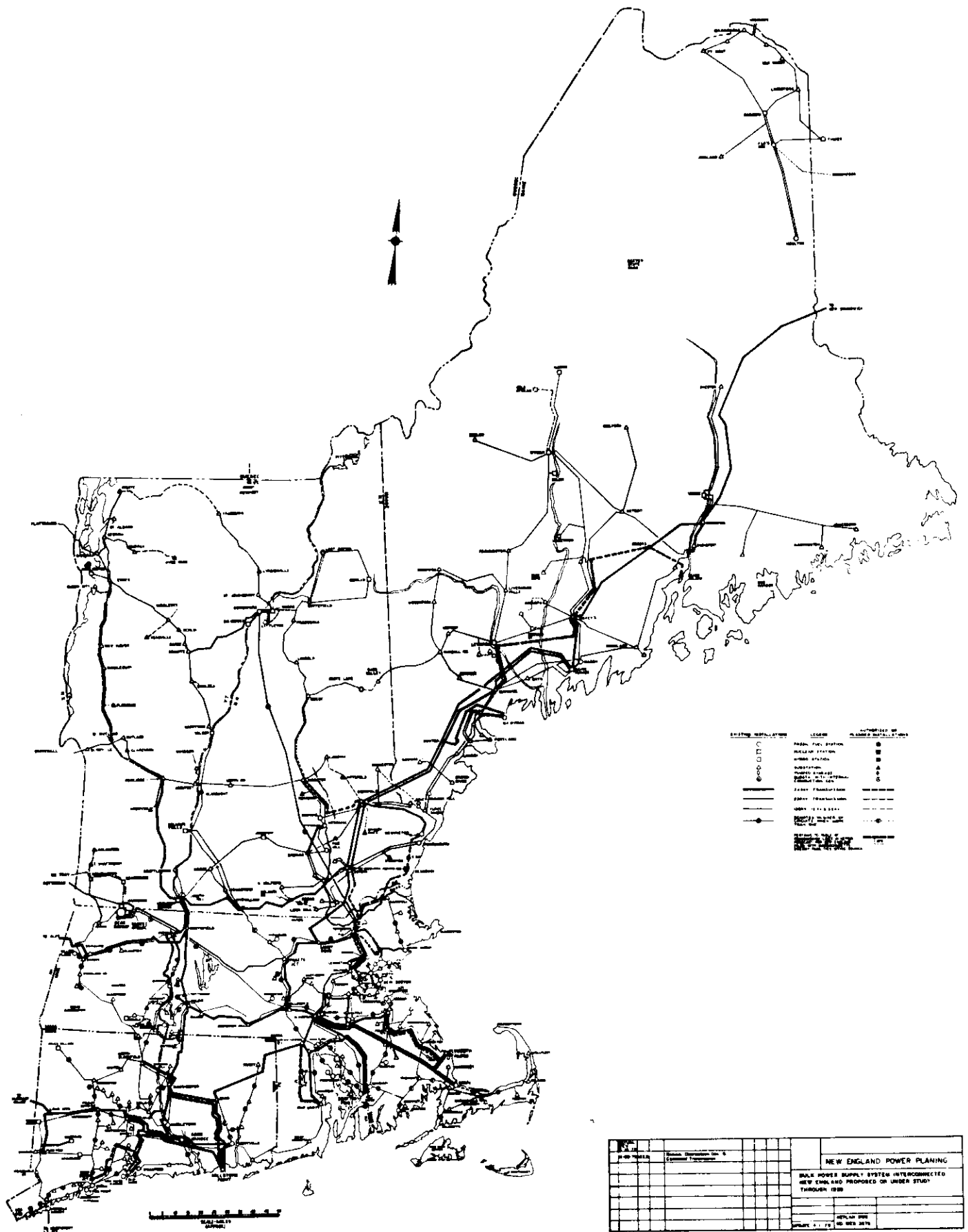


FIGURE 10



Commercial fisheries for soft-shell clams, worms, shrimp, flounder and lobster are expected to slowly decline. Resources in the bay area are, at present, declining, which can be expected to be the case in years to come. However, the success of mariculture development would have some influence on the value of fisheries in the future.

Harbor porpoises and seals would continue to depend upon the area for food, shelter, and reproduction. Whales would still be common in the bay providing their numbers in the open ocean remain constant.

Anadromous and catadromous species would not be impeded in their migration between the ocean and freshwater. Rivers would support self-sustaining populations provided that the fish passage facilities already present are kept in operation. Unless stocking programs are curtailed, those rivers that maintain populations by this method would continue to do so.

One factor that would effect all aspects of the aquatic ecosystem would be the construction of the Pittston Oil Refinery. The most important aspect here would be the possibility of oil spills in the bay which would have adverse effects on marine and freshwater resources. Reference is made to the Pittston Oil Refinery Final Environmental Impact Statement prepared by the Environmental Protection Agency, 1978, for a thorough discussion of these impacts (reference 41).

Those lands surrounding Cobscook Bay would remain in their present state. Wildlife populations would most probably maintain their present carrying capacity, providing there are no alterations in habitat. The structure, composition and diversity of the vegetative communities would not differ from the present. As timber harvesting occurs on a small scale, it would be reasonable to assume that there would not be an intensification of forest management practices in the project area.

Cobscook Bay and its surrounding lands would continue to support many species of upland birds, shorebirds, and waterfowl. However, should the Pittston Oil Refinery be built, this would be a factor affecting the avifaunal resources within the bay. Again, the possibility of oil spills would determine the effects on the present populations.

#### Cultural, Social and Economic Setting

Population growth will depend on the development of the county's resources. The long-term benefits and costs of major industrial development from outside the indigenous resource pool are unknown. In any case, it will probably cause major fluctuations in the population growth rate. Native resources, however, if developed, will probably provide a stable base for steady growth in the future as shown on Table 13 below.

Table 13  
POPULATION PROJECTIONS  
Washington County

<u>Age Group</u>	<u>1975 Population</u>	<u>1980 Population</u>	<u>1985 Population</u>	<u>1990 Population</u>
0-4	2,266	3,394	2,724	3,393
5-9	3,319	3,201	3,244	2,649
10-14	3,228	3,092	3,194	3,237
15-19	2,846	2,330	3,086	3,188
20-24	1,969	1,573	2,318	3,070
25-29	932	1,805	1,563	2,302
30-34	1,354	2,100	1,793	1,553
35-39	1,974	2,049	2,082	1,779
40-44	1,866	2,013	2,025	2,061
45-49	1,917	1,899	1,978	1,991
50-54	1,793	1,811	1,846	1,925
55-59	1,665	1,678	1,728	1,761
60-64	1,560	1,664	1,569	1,618
65-69	1,485	1,458	1,500	1,417
70-74	1,305	1,190	1,237	1,267
75+	1,432	1,651	1,469	1,302
Total	30,918	32,808	33,368	34,518

Source: Stone and Webster

Close to 70 percent of the county's land area is essentially unavailable to accommodate growth. As indicated earlier, 11 forest companies own 66 percent of Washington County's land area. The Tree Growth Tax Law which is applied to this acreage discourage conversion to other land uses. Furthermore, because of increasing demands for wood products, these companies have been acquiring more forest land in order to meet demands. In general, then, corporate-owned forest land will not be used to accommodate population growth. An additional 59,600 which is held in Federal and State game refuges, parks, and public lots, if off limits to growth. Indian reservations, accounting for just over one percent, also would not be available for development.

Therefore, approximately 500,000 acres, less than one third, of the county is left to absorb development pressures. This area is generally the coastal belt of towns along U.S. Route 1. The coastal section, for reasons of land availability, ownership patterns, essential services, etc., will bear the burden of any population growth in the future.

Within the coastal area, no single municipality can be predicted to grow at a rate faster or slower than the county as a whole. The factor which would influence settlement patterns including jobs, taxes, and land use regulations, are not expected to differ greatly from one town to

another in Washington County. However, any large development, employing a few hundred people, could unbalance the population distribution. Predicting the occurrence and magnitude of such a development could not be done with any certainty.

It is predictable that various kinds of development will be proposed. In addition to a tidal power project like this one, fisheries (inside and offshore), deep water ports, oil refineries, could be located here. This area, although sparsely populated, offers some development incentives that to a large extent are unavailable along much of the New England coast. However, no coastal plan has actually been developed which identifies the best areas for industrial growth. A discussion of any currently considered large scale industrial projects is included within the following sections.

All Maine communities possess certain tools with which to evaluate and regulate the use of at least some natural resources. These tools include shoreland zoning, the plumbing code, subdivision controls, clam ordinances, etc.

Although population in Washington County has been growing since 1970, it is difficult to judge whether it is a short range trend or one that would continue indefinitely because of the employment situation. Nevertheless, unanticipated growth places additional burdens upon a municipality's services and complicates land use priorities. Therefore, the need for land use controls is paramount in regulating desired development.

Historically such land use controls have been lax or non-existent in Washington County. The WCRPC in the develop of their Land Use Element for the Regional Comprehensive Plan identified several resources that could be threatened by uncontrolled land use development, including forest lands farmlands, clamflats, and the shoreline. In general, Washington County towns have been slow about implementing zoning or permit systems. Regulations imposed by State legislation have only been half-heartedly enforced. Land use regulation is fragmented into a number of different laws, ordinances, and regulations; administrative rests several different authorities.

It is expected that the present trends in recreational use and visitation to existing facilities in the region will continue. Most of the recreational attractions in the area are not terminal in nature and depend to a great extent on sightseers for the bulk of present visitation. Considering the continuing increases in gasoline prices as well as the cost of participating in many recreational activities, it is not expected that any dramatic increases in visitation to the region's present recreation areas will take place.

Most of the recreational needs and desires in Maine are for local urban facilities such as tennis courts, swimming pools and areas, playing fields, and recreation areas for children. None of these needs can be met by construction of a tidal poer project at Cobscook Bay. Recreational use

in the area probably won't change appreciably without construction of the project, whereas with the project existing facilities probably would receive more use and additional recreational facilities may be provided. However, any additional development would probably be limited due to the prevailing economic climate of the area and increasing travel costs. Without the project it is not likely that any new significant recreational development would take place in the Eastern Maine/Cobscook Bay area.

#### Electrical Energy Situation

If the project is not built it is likely that the energy which would have been produced by the tides will continue to be produced using oil. Total oil displacement by coal is unlikely. Major technological breakthrough regarding renewable resources are not predictable, however, it is reasonable to assume that such breakthroughs will not be developed to the extent that they can be intergrated on a large enough scale to displace all of New England's oil generation for several decades.

Electric load growth forecasting is difficult at best. In New England, NEPOOL is the primary source of such estimates. The most recent estimate, (April 1980), anticipates winter and summer peaks of 24,170 MW and 19,280 MW, respectively, for the year 1995. Planned system capability for that period, taking into account retirements, purchases and additions are in excess of 27,000 MW. It is expected that energy demand will increase at a rate of 2.6 percent per year. It is also projected based on planned additions purchases and retirements that the fuel mix prevailing in 1995 will be approximately as shown in Table 14.

Table 14  
Projected 1995 Generation Mix  
(Percent of Total Generation)

<u>Fuel</u>	<u>Percent of Total Generated</u>
Hydro	11.7
Coal	17.3
Nuclear	33.2
Oil	37.8

Table 15 below shows NEPOOL's planned generation additions through 1995 (reference 20). That report contains data on planned purchases, retirements and year growth as well. Figure 11 is a graphic representation of NEPOOL's anticipated peak inter day in 1994-95

TABLE 15

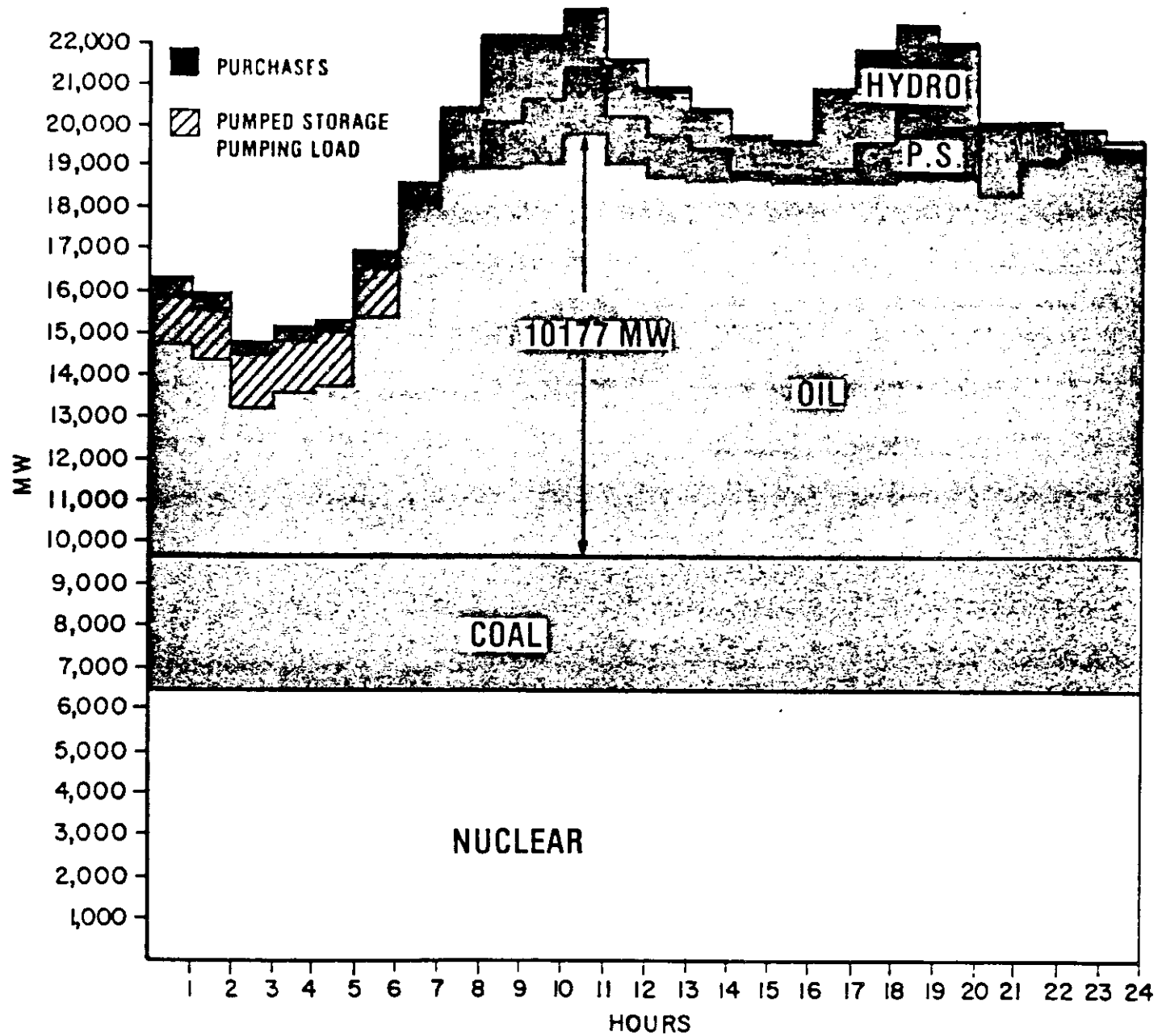
## COMMITTED AND PLANNED CHANGES IN GENERATING EQUIPMENT THROUGH 1995

SYSTEM	STATION & UNIT	UNIT TYPE#	FUEL TYPE ##	NEPOOL STATUS <sup>X</sup>			CAPABILITY		EFFECTIVE DATE	
				PLANNED	(A) (A*)	MFG.	NOM. CAP. MW	SUMMER - WINTER	MONTH	YEAR
				UNDER STUDY	(S)					
Northeast Utilities	Dwight #2-4	Hy	--	A		--	1.50	1.50	Jan. 1, 1980	
Central Maine Power Company	Barkers Mill	Hy	--	A		--	1.50	1.50	Feb. 1, 1980	
Northeast Utilities	Bantam	Hy	--	A		--	0.32	0.32	June 1, 1990	
Chicopee Municipal Light Plant	-- #1,2,3	IC	FO2	A		GM	8.25	8.25	Nov. 1, 1980	
New England Electric System	Lawrence #1&2	Hy	--	A		--	17.00	17.00	July 1, 1981	
Mass. Municipal Wholesale Electric	Stony Brook	CC	FO2	A*		GE	279.00	341.00	Nov. 1, 1981	
Public Service Co. of New Hampshire	Garvins #1&2	Hy	--	A		--	6.00	6.00	Nov. 1, 1981	
Central Maine Power Company	Brunswick/Topsham	Hy	--	A		--	12.00	12.00	Mar. 1, 1982	
Vermont Group	Bolton Falls	Hy	--	P		--	4.20	5.60	May 1, 1982	
Hudson Electric Light Dept.	Cherry St. #13, 14, 15	IC	FO2	S		--	18.00	18.00	Nov. 1, 1982	
Mass. Municipal Wholesale Electric	Stony Brook	GT	FO2	A*		GE	130.00	170.00	Nov. 1, 1982	
Mass. Municipal Wholesale Electric	-- #1	ST	REF	S		--	75.00	75.00	Nov. 1, 1982	
Public Service Co. of New Hampshire	Murphy Dam	Hv	--	P		--	2.00	2.00	Nov. 1, 1982	
Vermont Group	Chase Mills	Hy	--	S		--	6.00	8.00	Nov. 1, 1982	
Public Service Co. of New Hampshire	Seabrook #1	NP	UR	A*		W/GE	1150.00	1150.00	Apr. 1, 1983	
Northeast Utilities	Hadley Falls #2	Hv	--	A		--	15.00	15.00	June 1, 1983	
Mass. Municipal Wholesale Electric	-- #2	ST	REF	S		--	75.00	75.00	Nov. 1, 1983	
Vermont Group	E. Georgia	Hy	--	S		--	6.50	8.60	Nov. 1, 1983	
Vermont Group	J.C. McNeil #1	ST	FO2	P		--	46.00	46.00	Nov. 1, 1983	
Public Service Co. of New Hampshire	Seabrook #2	NP	UR	A*		W/GE	1150.00	1150.00	Feb. 1, 1985	
Boston Edison Company	(Fuel Cell)	FC	FO1	P		UT	10.00	10.00	Aug. 1, 1985	
Vermont Group	Missisquoi	Hv	--	S		--	17.20	22.80	Nov. 1, 1985	
Boston Edison Company	Pilgrim	NP	UR	A*		CE/GE	1150.00	1150.00	Dec. 1, 1985	
Northeast Utilities	Millstone Pt.#3	NP	UR	A*		W/GE	1150.00	1150.00	May 1, 1986	
Vermont Group	N. Hartland	HY	--	S		--	1.90	2.60	Nov. 1, 1986	
Central Maine Power Company	Sears Island	ST	Col	A*		--	568.00	568.00	Nov. 1, 1989	
Boston Edison Company	Edgar #7	ST	Col	S		--	800.00	800.00		1992
NEGEA / EUA	Canal #3	ST	Col	S		--	600.00	600.00	Nov. 1, 1992	

# NEW ENGLAND PEAK DAY DISPATCH - WINTER 1994/95

EXHIBIT 12

24 Units Converted to Coal & NEPOOL Planned Units



## Problems, Needs and Opportunities

The Cobscook Bay Tidal Power study was undertaken to determine whether it is feasible to develop electric energy using the large tide range that exists in the vicinity of Eastport, Maine. The concept is not new. It has been repeatedly studied since 1919 when Dexter P. Copper first conceived the idea. The problem is apparently not technical, as every group that has studied the concept since 1935 has found it to be technically feasible. In fact, similar projects have been built in the Soviet Union and France. What are the problems? Essentially there are three concerns:

1. Is the project economically feasible?
2. Are potential environmental impacts which could result from the project acceptable?
3. Can the project's power be utilized effectively?

If a feasibility study is undertaken following this report these questions along with several salient technical questions will be the focus of that study.

If the project is built it will displace almost exclusively, energy that would otherwise have to be generated using oil. Clearly based on the previous section, New England's energy security situation would be enhanced by reducing oil dependency. The need for such a project, or for that matter any project, that uses renewable resources, is apparent.

New England is fortunate in a few ways with respect to energy sources. It has wood and water in abundance. It also has the unusually large tide range found at Cobscook Bay. Wood, though renewable, is not nearly as attractive as hydropower or any of the other solar technologies (direct, wind, passive). The reason for this is simple, it takes several years to renew the wood resources while solar resources, tides, runoff, wind, sunlight are continuously renewed. Unfortunately a review of either the Corps of Engineers National Hydroelectric Study or the Regional Hydropower expansion study managed by the New England River Basins Commission reveals the limited nature of our hydropower resource. Figure 12 shows existing dams in Washington County which have been subjected to a preliminary screening by Corps of Engineers for the New England River Basin Commission. Based on preliminary analysis assuming run of river operation of all the sites listed could produce energy for less than 100 mils/kwh. As detailed studies are made it is expected the costs will increase.

It is not likely that any new large hydropower projects with storage capability will be built. In fact, it is still not known whether the long planned, economically attractive Dickey-Lincoln project will be built. Most hydropower development will probably be limited to run of river seasonal operation and have little or no dependable capacity.

Nuclear power expansion has essentially stopped during the last few years. No one knows what the future of nuclear power is in New England



HYDROPOWER POTENTIAL AT EXISTING DAMS  
IN WASHINGTON COUNTY

Project Name	Community	River/Stream	Capacity Kw	Energy Mwh	Mills/Kwh
1. Columbia Falls	Columbia Falls	Pleasant River	505	1,775	96.5
2. Upper Dam	Pembroke	Penamaquan River	471	1,479	91.3
3. Danforth Dam	Danforth	Crooked Brook Falls	517	1,808	83.9
4. Cherryfield	Cherryfield	Naraguagus	698	2,422	75.1
5. Whitneyville Upper	Whitneyville	Machias River	2,376	8,352	74.0
6. Machias River Dam 3	Machias	Machias River	743	2,610	73.3
7. E. Machias River Dam	E. Machias	E. Machias River	1,133	3,981	72.7
8. Whitneyville Lake	Whitneyville	Machias River	1,485	5,220	72.5
9. W. Grand Lake Outlet	Grand Lake Stream Plantn.	Big Lake Lower	941	3,293	67.7
10. Orange River Dam	Whiting	Orange River	416	1,462	57.6
11. Meddybemps Lake	Meddybemps	Meddybemps Lake	417	1,467	57.4
12. Vanceboro Dam	Vanceboro	St. Croix River	1,583	5,542	53.7
13. Machias River Lower Dam	Machias	Machias River	3,003	10,556	52.1
14. Machias River Dam 2	Machias	Machias River	2,970	10,440	44.6
15. Murchie Dam	Calais	St. Croix River	4,004	14,014	44.0
16. Saco Falls Dam	Columbia	Pleasant River	1,271	2,381	42.1
17. Mill Town Dam	Calais	St. Croix River	4,939	17,287	39.6
18. Calais Union Dam	Calais	St. Croix River	4,528	15,847	37.7
19. Machias River Dam 4	Machias	Machias River	4,158	14,616	23.1
Total			36,108	124,552	



now It is known, however, that in the short term, it is the cleanest, most technically proven method of displacing large amounts of oil generation.

Coal and the environmental problems associated with it are under study. Presently only two coal plants operate in New England, one in Massachusetts and one in New Hampshire. They handle only a small part of New England's demand.

So as we approach the year 2000 in New England it is likely that a great deal of emphasis will be placed on solar resources, sun, winds, tides and water as we attempt to displace oil-fired electric generation.

The tidal project is one such resource and, like hydropower, it is proven, works at relatively high efficiencies and the technology is available now.

#### Planning Constraints

General planning constraints and guidance for this investigation are contained in Public Law 91-190, National Environmental Policy Act; Public Law 91-611, River and Harbor and Flood Control Act of 1970; Public Law 92-500, Federal Water Pollution Control Act Amendments of 1972; Public Law 93-251, Water Resources Development Act of 1974; and the Water Resources Council's "Principles and Standards for Planning Water and Related Land Resources."

Specific guidance is found in the following Department of the Army regulations; ER 1105-2-14, ER 1105-2-50, ER 1105-2-210, ER 1105-2-220, ER 1105-2-230, ER 1105-2-240, ER 1105-2-250, ER 1105-2-507, ER 1105-2-800 and ER 1105-2-921.

The purpose of these laws and regulations is to insure that a planning process is adhered to under which alternative plans are formulated and that the resulting economic, social, and environmental impacts are assessed and evaluated.

#### Planning Objectives

Planning Objectives in this study reflect national and regional needs specific to the tidal power investigation. It should be noted that the order of the objectives is not intended as an indication of their relative importance. Producing electric energy utilizing the large tide range at Eastport is of primary importance, as it is the basis for the study authority. As the study progresses, the planning objectives will be refined and modified with the possibility of some being dropped from further consideration. It is also possible that as the study progresses additional objectives may be identified and added. The planning objectives recognized at this time include:

- determination of whether it is technically and economically feasible to build a conventional tidal power generating facility which utilizes the large tide range experienced at Eastport, Maine
- reduction of national and regional dependence on oil for electric energy production
- improvement of New England's "energy independence"
- encouragement of the development of native renewable energy resources
- minimization of potential adverse environmental impacts of a tidal power project
- promotion of economic activity in the study area.

### III FORMULATION OF PLANS

#### Management Measures

There are a number of management measures which may be employed to reduce New England's dependence on oil for the production of electrical energy and to satisfy other planning objectives as well. Structural measures include conversion of oil fired facilities to coal, building additional coal and nuclear facilities, construction of hydroelectric and tidal power projects, and development of alternative energy sources including, but not limited to wind, passive solar, coal liquification photovoltaics, wave action, geothermal, wood, and other biomass and purchases of imported power. Non-structural measures would consist mainly of conservation and load management. A brief discussion of the primary function of each measure, including inherent advantages and disadvantages is presented below.

Conversion of oil facilities to use coal as a fuel directly reduces the amount of oil needed for electric energy production. The concept is technically sound and economically implementable at many facilities. The conversion, however, is not without problems. Key factors that must be considered are the availability of water or rail transportation facilities and protection of ambient environmental quality.

The construction of new coal and nuclear facilities also directly reduces oil use. New coal facilities have problems similar to converted facilities and the current social-political climate in New England makes development of nuclear projects difficult if not impossible.

Hydroelectric facilities including run of river, pumped storage, conventional and tidal power also directly reduce the amount of oil used for generation. While these projects do not degrade air quality, or create dangerous waste materials they tend to permanently alter existing physical conditions at the project site. Sometimes they displace inhabitants and adversely effect resident wildlife. The fuel, water, is a renewable resource.

Wind power is one of the oldest forms of energy. Windpower is clean and many sites are available. Energy from such projects is intermittent, as is energy from single pool tidal power projects and run of river hydro-power projects. Energy from such projects is dependent on natural phenomena, wind, tides and runoff. Man cannot control when fuel will be available. Of course in the case of tidal power or run of river power energy availability can be predicted with a reasonable accuracy. Wave action offers promise on a small scale. Passive solar is basically an at-site technology. It is useful for space and hot water heating. It is not particularly adaptable to large centralized facilities. Liquified coal, photovoltaics, nuclear fusion and biomass will, perhaps, be the predominant energy source of the 2000's. Once fully developed, these technologies could lead to energy independence for the Nation.

Purchases of imported power would reduce our direct dependence on oil but do little to enhance our energy independence.

Conservation is perhaps the best short term answer to oil use reduction. Smaller more efficient automobiles, lower thermostats, insulation and other conservation methods directly reduce oil use and have limited impacts on changes in life style.

Load management is primarily aimed at rearranging the timing of electric demand. This involves the changing of people's habits. Once established, load management would allow more use of base load and intermediate power sources (lower cost, less oil dependent coal, nuclear and hydroelectric) and require less peaking power (expensive pumped storage and oil dependent combustion turbines). Of course, load management assumes that nuclear and coal energy will continue to be available and increase.

#### Plan Formulation Rational

The purpose of this investigation is to determine the feasibility of developing tidal power by taking advantage of the large tide range experienced in the Passamaquoddy Bay area. Therefore alternative studies do not include all the management measures indicated in the previous section. Any of the measures mentioned would help to reduce oil consumption and be compatible with any possible tidal power project.

In 1979, a number of tidal power alternatives located entirely within Cobscook Bay were subjected to a preliminary economic analysis. Single pool and multipool projects ranging from 4-450 megawatts were considered. None of the alternatives analyzed were found to be economically feasible using conventional, static benefit to cost analysis. However, some of the larger single pool projects were found to be economically acceptable using certain fuel price escalations and a dynamic benefit to cost ratio analysis known as relative price shift analysis. Single pool alternatives with large areas of the bay impounded and relatively small installed capacities were found to produce energy at the lower costs per kilowatt hour than did small linked basins or paired basins. Such single pool projects generate energy twice daily at different times each day with the time of occurrence being dependent on the tide cycle. The single pool projects have no dependable capacity and no monetary value associated with the capacity. While multipool plans provide for some dependable capacity and amount of installed capacity 3 to 4 times greater than the dependable capacity must be provided. In other words, a great deal of money must be spent on turbines and generators whose total potential is never realized. Generally, then, that study seemed to indicate that large single pool projects allow maximum utilization of the tidal resources. It was found that lowest cost energy could be produced when single pool project turbines and generators were sized to operate for 5 to 6 hours per tide cycle on the average. The unique relationship installed capacity and energy produced from a project for a period of time is referred to as a "capacity factor." The work done for the 1979 report strongly suggested that for single pool tidal power alternatives projects sized and operated to have a

capacity factor around 0.4 might produce energy at a lower cost per kilowatt hour than other configurations.

Based on these preliminary economic findings four single pool plans were selected for more detailed analysis in this study. One small single pool plan and three large single pool plans were considered in this study. If future studies are found to be warranted a two pool plan and a scheme involving multiple small single pool plans will be addressed in sufficient detail to determine if such schemes are indeed economically inferior to large single pool plans as indicated by the 1979 study and to ascertain the environmental impacts associated with their development.

#### The Plans of Others

Currently a study of a small single pool 10 megawatt tidal power project within Cobscook Bay is being studied by the Passamaquoddy Indians. The project, known as Half Moon Cove, has been under study for the past several years. On 19 June 1980, the Federal Energy Regulatory Commission granted a preliminary permit to the Passamaquoddy Tribal Council. This permit allows the tribe to study Half Moon Cove for tidal power feasibility for up to three years. At this time, New England Division is not aware of current cost estimates for the proposed project.

Owing to the Half Moon Cove project and the long history of the tidal Power study in the region, local residents of the area have formed a Tidal Power Committee. While New England Division has never been formally aware of the existence of this group it appears from news clippings that the committee is interested in the development of several small, electrically interconnected, tidal power projects including Half Moon Cove.

#### Description of Plans

As previously mentioned all the plans under consideration are single pool projects. A single high pool system is one in which a barrier cuts off a single tidal basin from the ocean. The basin pool is filled when the ocean tide level is higher than the pool level and the barrier is closed when the ocean tide falls. Power is generated during the period when the ocean level is lower than the pool level by discharging water through turbines from the pool to the ocean. The pool is filled by the operation of filling gates, and no power is generated during filling nor is generation started until sometime after filling has been accomplished. Although such a system produces "reliable" energy, it is neither continuous nor available on demand. Some operating flexibility might be possible within a given low tide cycle based on short-term load demand forecasts. Theoretically, the systems process could be reversed and generation takes place by discharging into a low single pool; however, the high pool system is usually preferred since change in pool level per unit discharge is less in the upper levels of the basin.

The major structural elements of a tidal power project as planned are a powerhouse, gates, a lock, a fishway and large earth and rockfill dams.

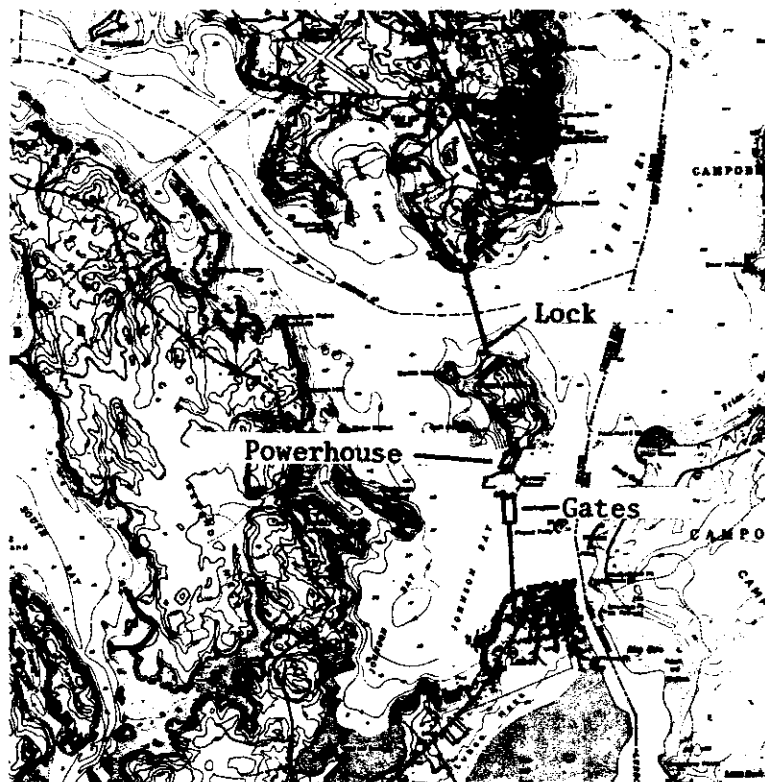
Figure 12 shows the location of each of the four alternatives and briefly describes the pertinent features of each alternative. The "Wilson alignment" impounds East Bay and the Pennamaquan River with a dam that originates at Leighton Neck, passes through Wilson Ledges and Red Island, terminating at Birch Point. The "Birch alignment" impounds the Inner Bay, South Bay and East Bay and originates at Birch Point and terminates at Seward Neck. The "Goose alignment" impounds the same areas as the Birch alignment with the addition of Half Moon Cove and originates at Seaward Neck, passes through Goose Island and Mathews Island to Moose Island. The "Dudley alignment" follows the 1935 dam alignment and impounds all of Cobscook Bay. It originates at Eastport, passes through Treat and Dudley Islands and terminates at Lubec. The Dudley alignment is significantly different than the 1935 alignment, however, in that the powerhouse is located between Treat and Dudley Islands instead of on Moose Island between Johnson Cove and Carrying Place Cove. Figure 14 shows the pertinent features of the 1935 alignment. The primary reasons for the Moose Island powerhouse location in 1935 was that it would allow further development on an international plan that involved both Passamaquoddy Bay and Cobscook Bay. Given Canada's current position of non-interest in the pursuit of an international plan and the economies to be realized by locating the powerhouse between Dudley and Treat Island this change in plan seems reasonable.

#### Design Considerations

##### Foundations

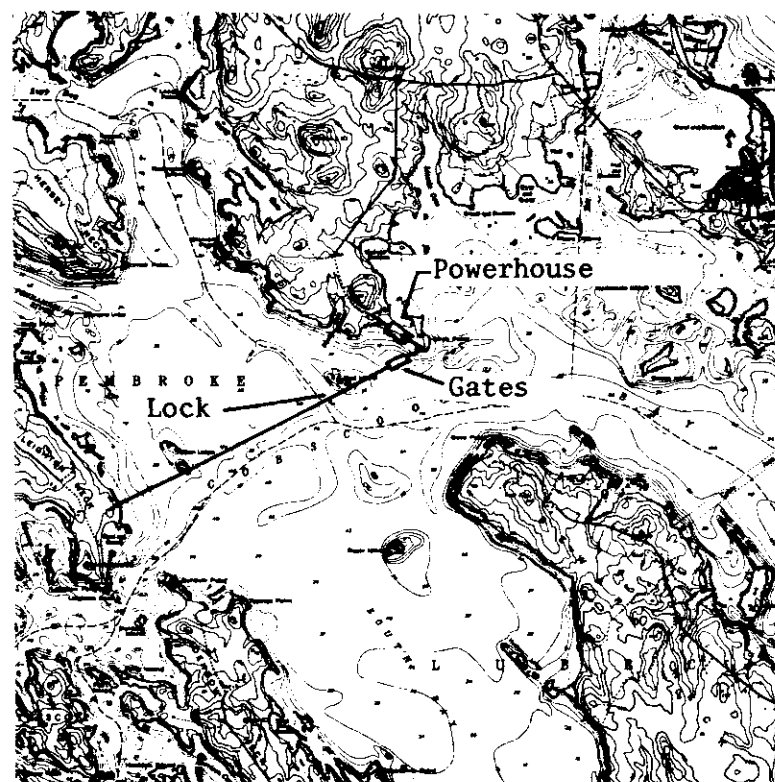
Explorations for the proposed alignments consisted of borings made at the Dudley site in 1936 and a seismic reflection survey of the four alignments under study as shown on Figure 15. The seismic reflection reconnaissance surveys were conducted in May 1979 and consisted of multiple lines at each of the sites. No direct velocity data was made during the survey. The estimate of the average velocity of the sediments was achieved by correlation of data along seismic lines on the North Dudley site with geologic profiles prepared on the basis of explorations made in 1936. By calibrating the survey with the known geologic conditions at the North Dudley site a maximum degree of reliability was obtained for the site surveys. No explorations have been made on the alignments to verify assumed foundation conditions shown.

The sediment types have been inferred based upon consideration of exploration data on the Dudley sites, and a literature search dealing with the geology and geologic history of the area and the texture of the seismic reflections as they appear on the graphic records. No attempt has been made to delineate rock types on the geologic profile. In general, previous foundation studies on earlier structures have indicated that the rock is sufficiently competent for most concrete structures. Design of individual



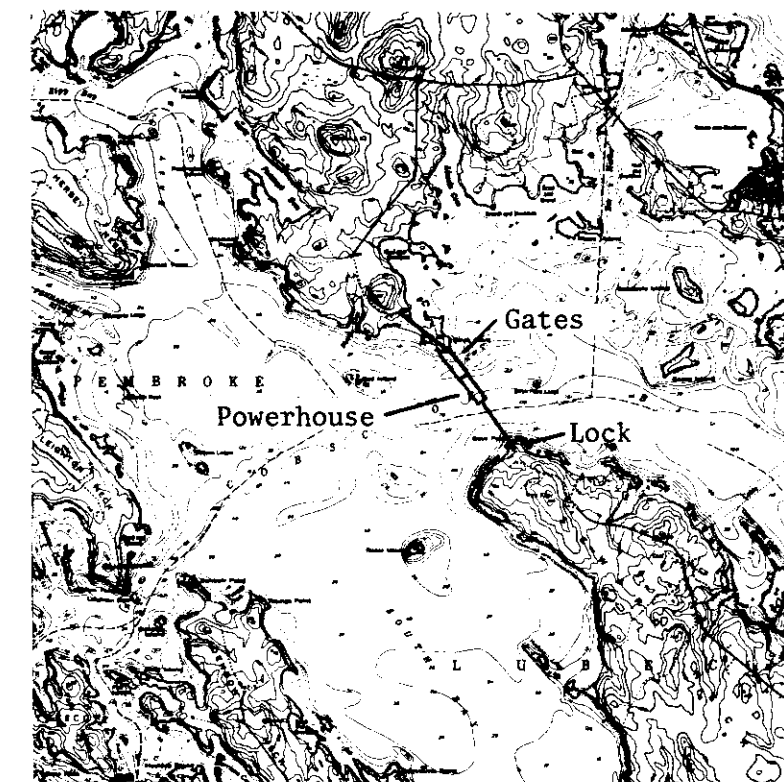
Dudley Alignment - Would consist of an earth and rockfilled dam approximately 1.5 miles in length with a maximum height of 140 feet. At high tide the dam would impound an area of 39.5 square miles. Installed capacities ranging from 120 MW to 970 MW with average annual energies ranging from 470 GWH to 1420 GWH were investigated.

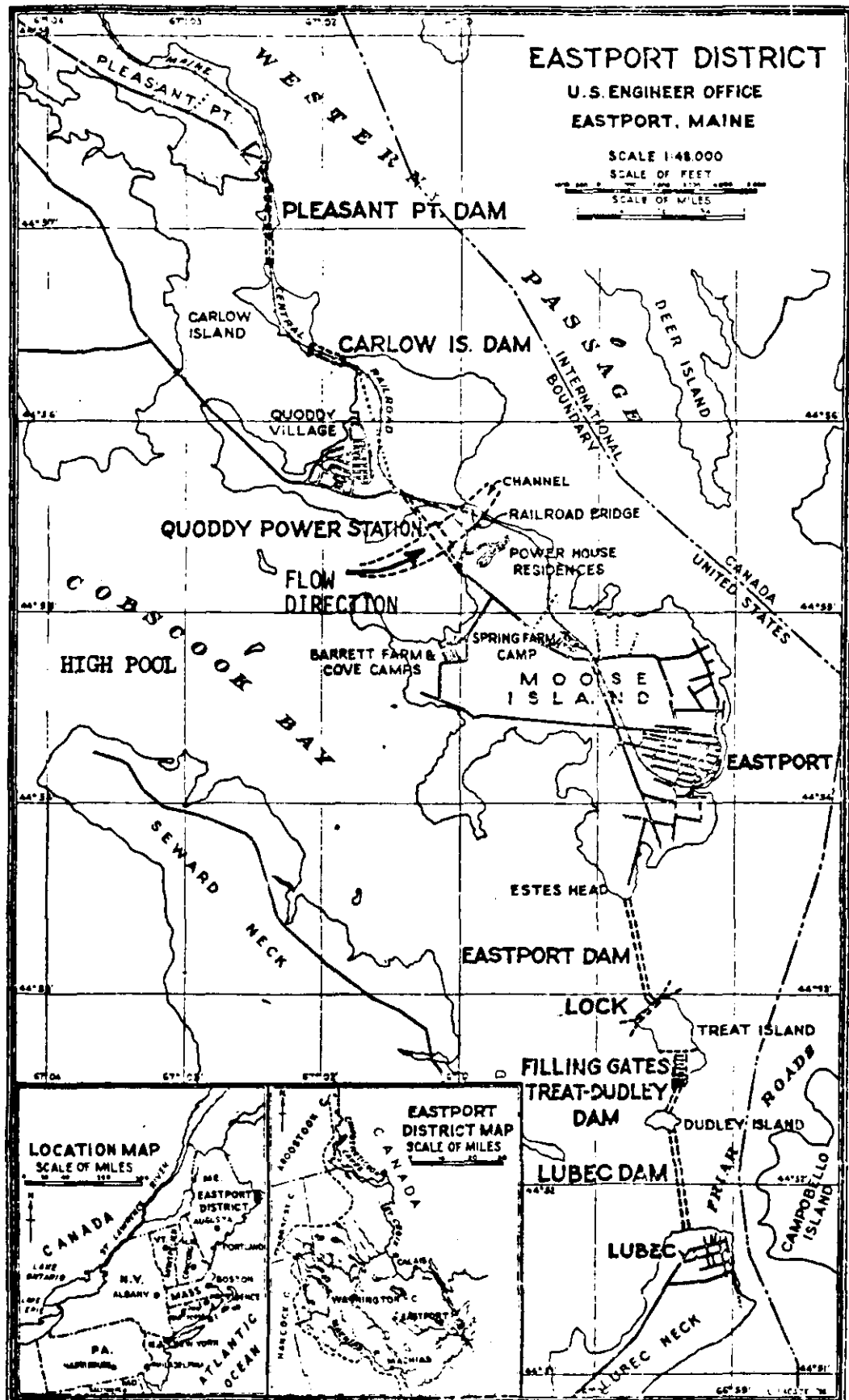
Goose Alignment - Would consist of an earth and rockfilled dam approximately 2.0 miles in length with a maximum depth of 125 feet. At high tide the dam would impound an area of 33.5 square miles. Installed capacities ranging from 100 MW to 815 MW with average annual energies ranging from 400 GWH to 1215 GWH were investigated.



Wilson Alignment - Would consist of an earth and rockfilled dam approximately 2.5 miles in length with a maximum depth of 90 feet. At high tide the dam would impound an area of 6.0 square miles. Installed capacities ranging from 18 MW to 150 MW with average annual energies ranging from 70 GWH to 220 GWH were investigated.

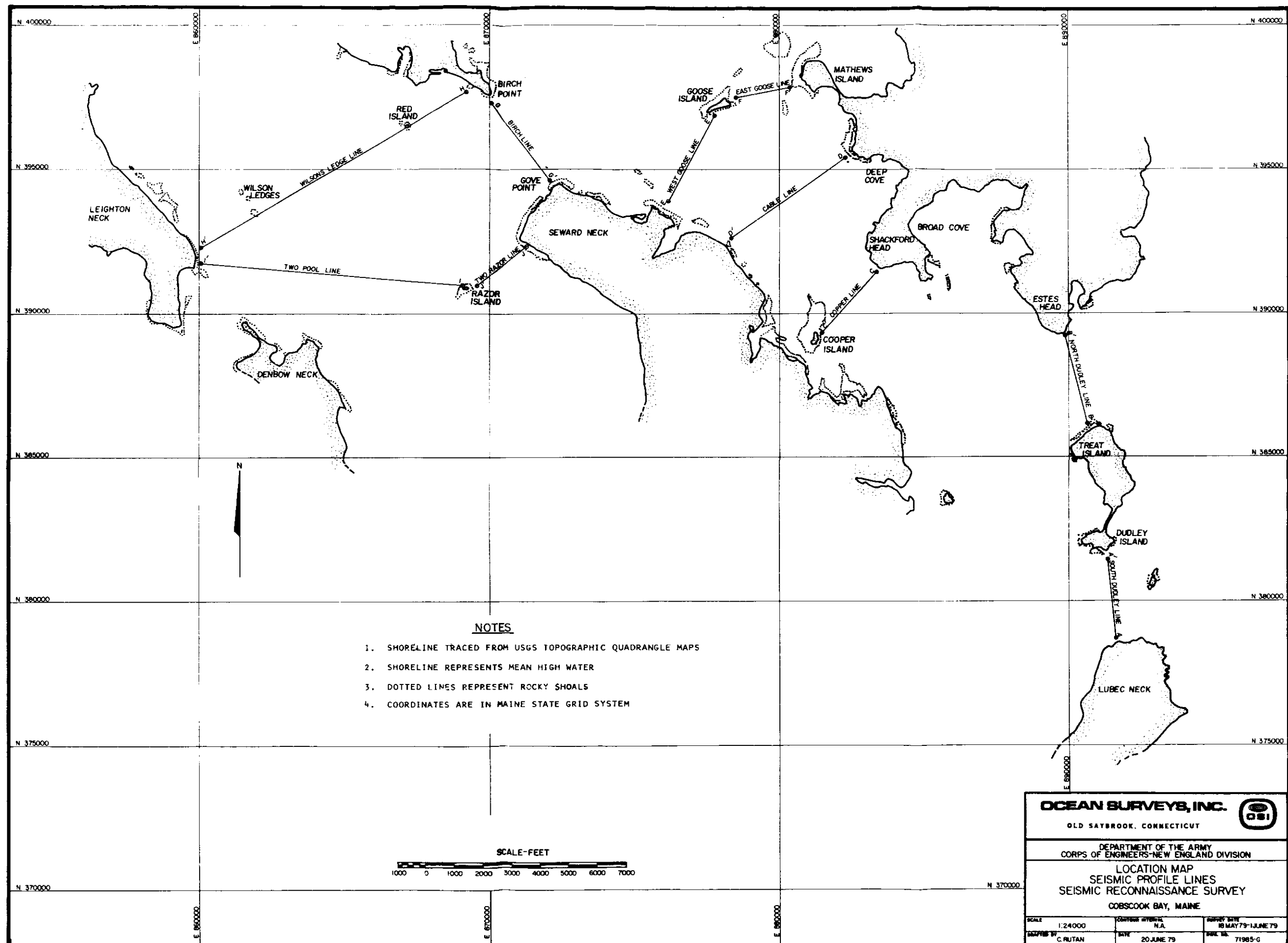
Birch Alignment - Would consist of an earth and rockfilled dam approximately 1.0 miles in length with a maximum depth of 115 feet. At high tide the dam would impound an area of 28.5 square miles. Installed capacities ranging from 80 MW to 700 MW with average annual energies ranging from 340 GWH to 1040 GWH were investigated.

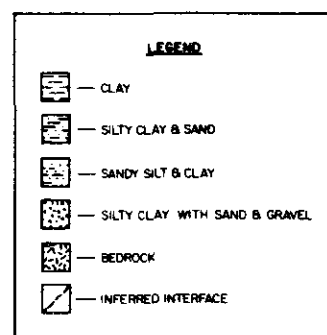
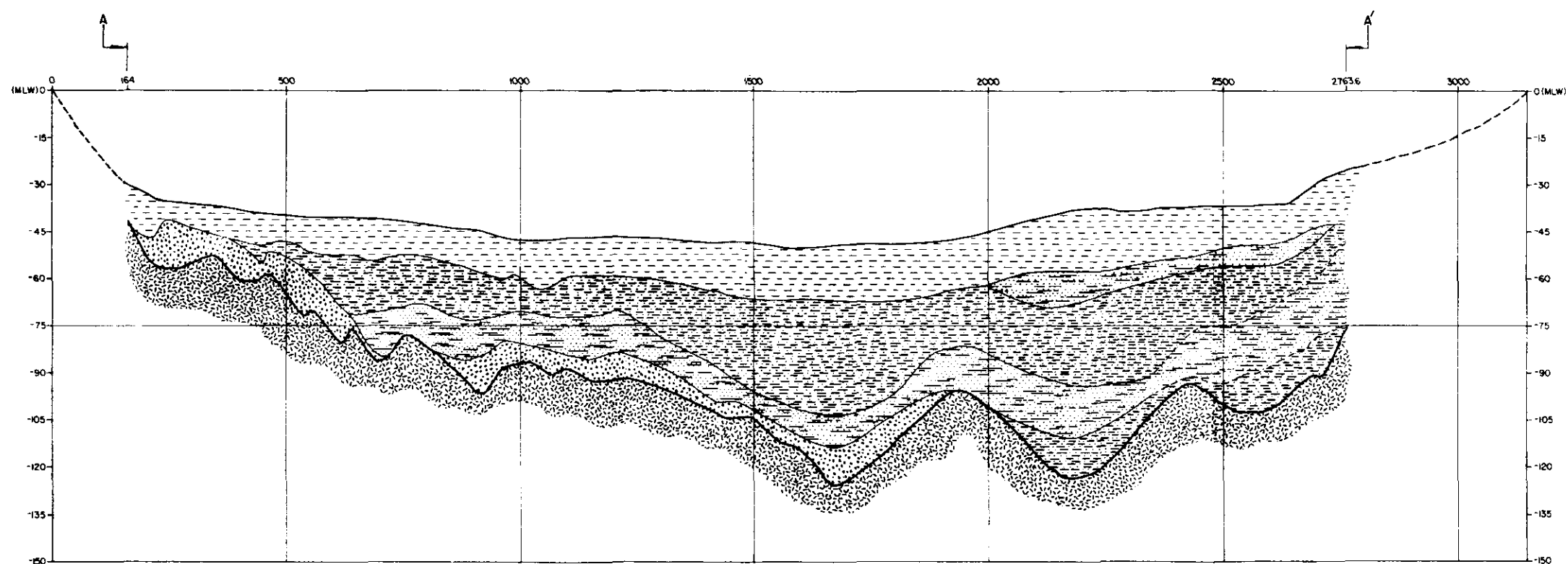
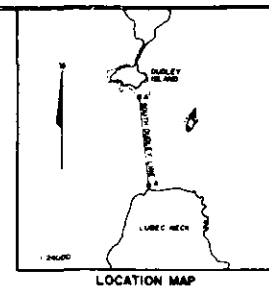




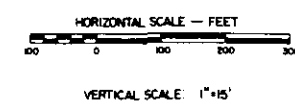
COBSCOOK BAY - 1935  
 FIGURE 14



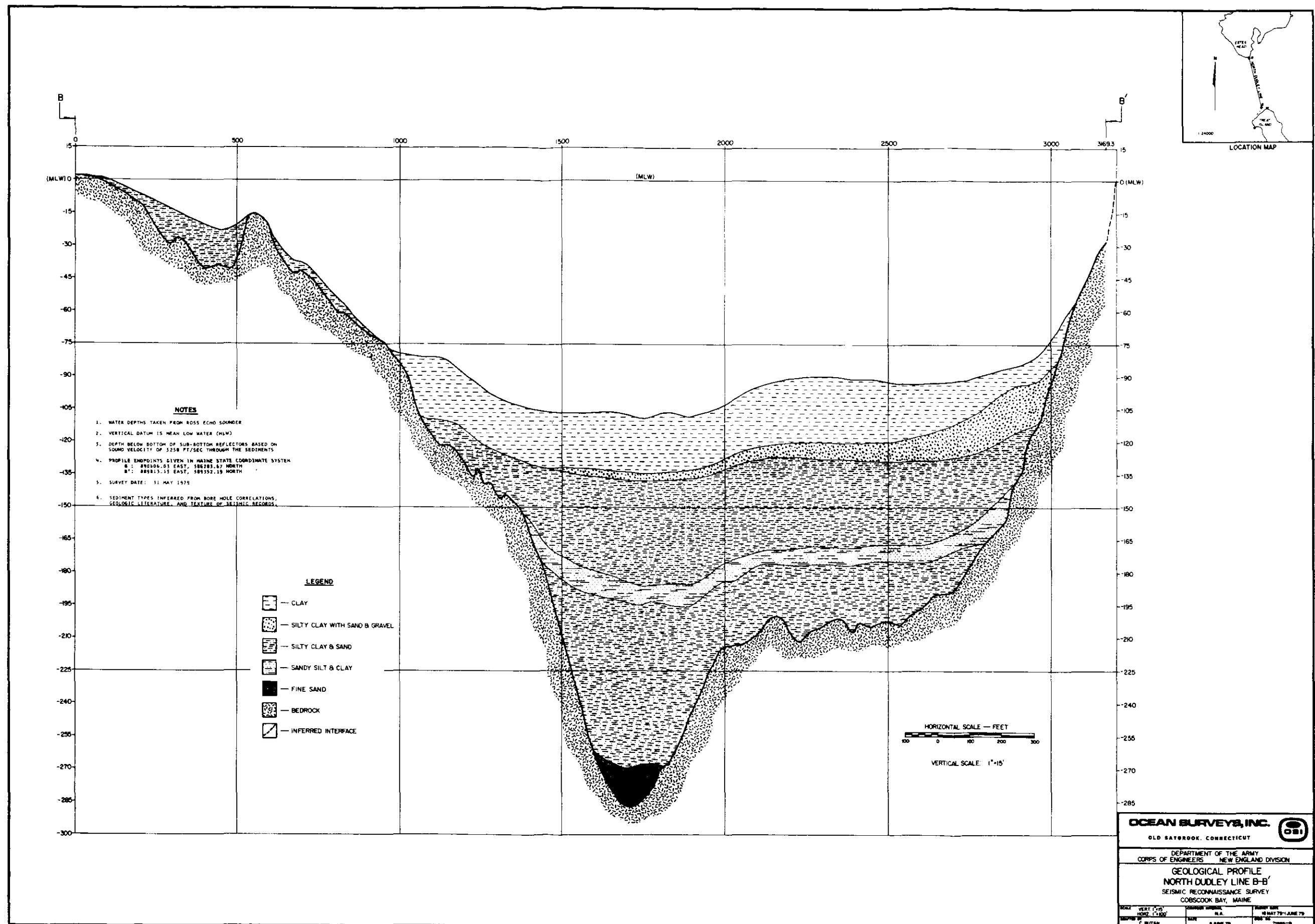


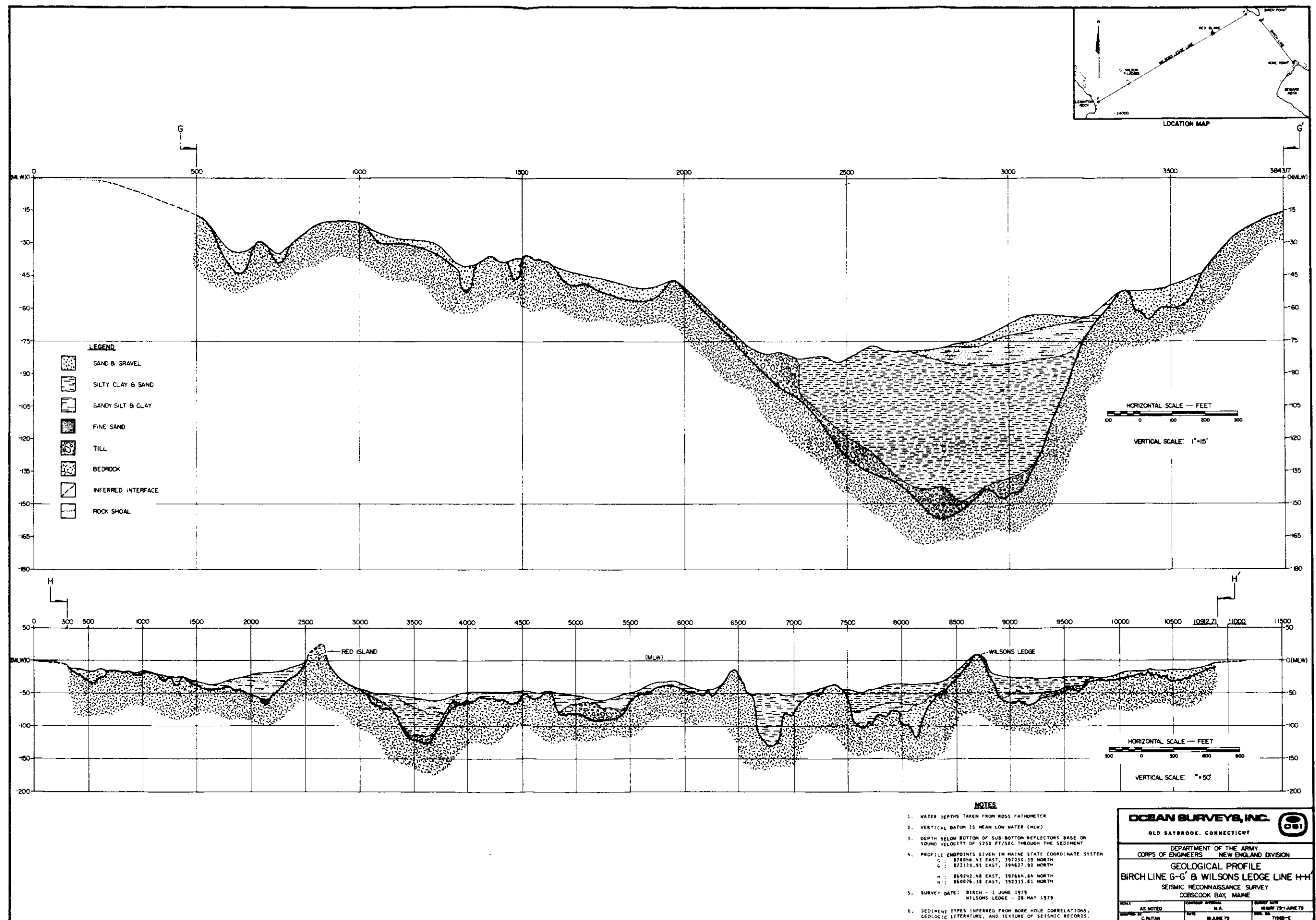


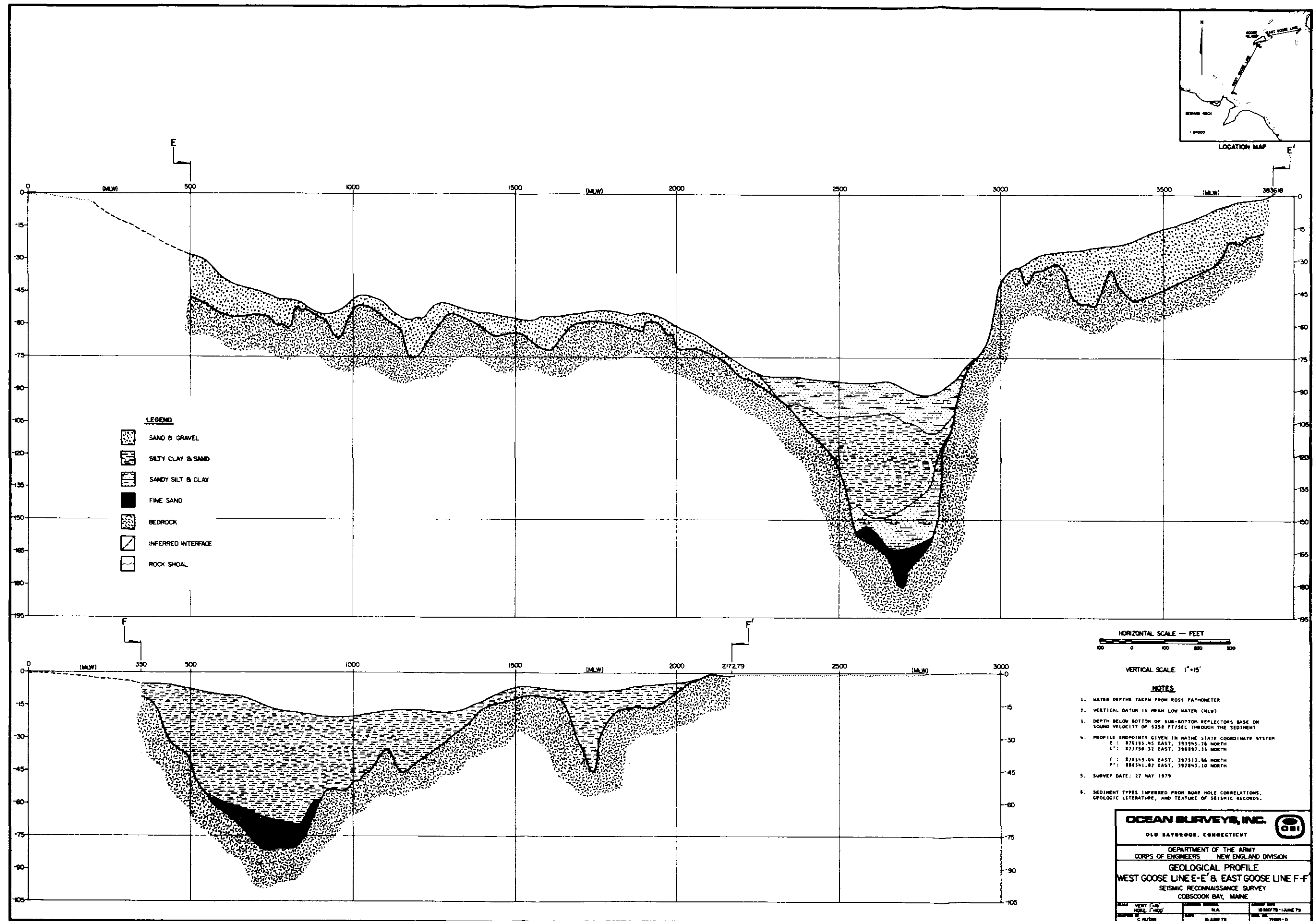
- NOTES**
1. WATER DEPTHS TAKEN FROM ROSS ECHO SOUNDER
  2. VERTICAL DATUM IS MEAN LOW WATER (MLW)
  3. DEPTH BELOW BOTTOM OF SUB-BOTTOM REFLECTORS BASED ON SOUND VELOCITY OF 5250 FT/SEC THROUGH THE SEDIMENTS
  4. PROFILE ENDPOINTS GIVEN IN MAINE STATE COORDINATE SYSTEM  
A : 881508.53 EAST, 328044.78 NORTH  
A' : 881538.36 EAST, 381568.33 NORTH
  5. SURVEY DATE: 31 MAY 1979
  6. SEDIMENT TYPES INFERRED FROM BORE HOLE CORRELATIONS, GEOLOGIC LITERATURE, AND TEXTURE OF SEISMIC RECORDS.



<b>OCEAN SURVEYS, INC.</b>			
OLD SAYBROOK, CONNECTICUT			
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION			
GEOLOGICAL PROFILE SOUTH DUDLEY LINE A-A' SEISMIC RECONNAISSANCE SURVEY COBSCOOK BAY, MAINE			
SCALE	VERT. 1"=15'	CORRESP. SHEET	REMARKS
DATE	11 APR 79	BY	11 APR 79
BY	C. M. TAYLOR	DATE	11 APR 79







structures would be based on the rock structures at the particular location.

The project is located in Zone 1 on the Seismic Probability Chart for the United States. The Seismic Zone Map indicates that damage in this zone would be minor with a seismic coefficient for design of .025. A cursory review of available historical data reveals, however, that approximately 30 earthquake epicenters have been recorded within 75 miles radius of the project area in the United States and Canada. Of this number the majority of the earthquakes were in the intensity ranges of I to IV with a maximum earthquake of an intensity VIII occurring in the Bay of Fundy approximately 35 miles west of the site. Closer to the site an earthquake of intensity VII occurred on 21 March 1904 at 6:00 a.m. This earthquake which was documented in records by the National Earthquake Information Service (NEIS) and the Earthquake History of the United States (EHUS) was felt over an area of 150,000 square miles. The proximity to the project site of these reported epicenters will require further documentation as their presence may influence the design of structures.

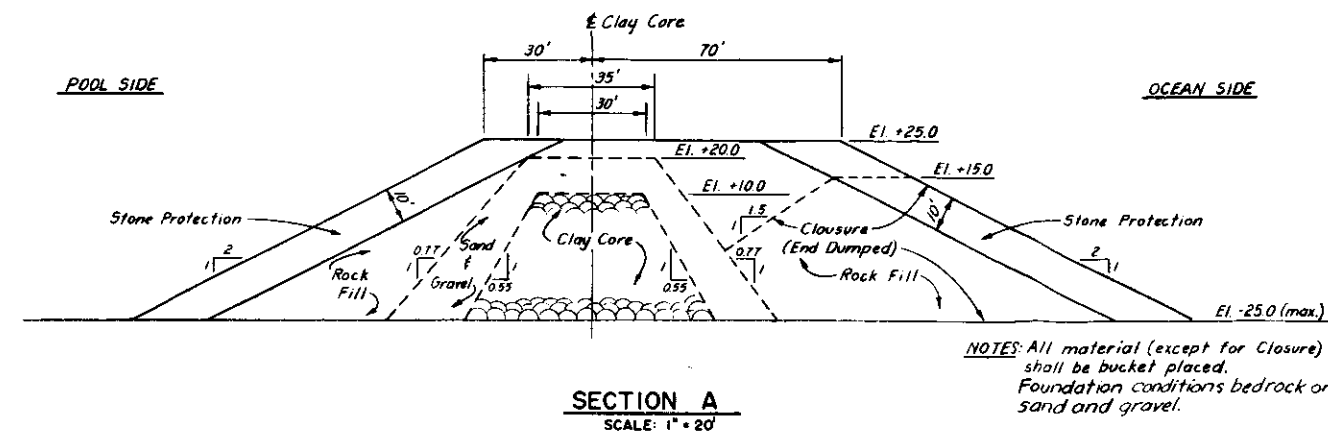
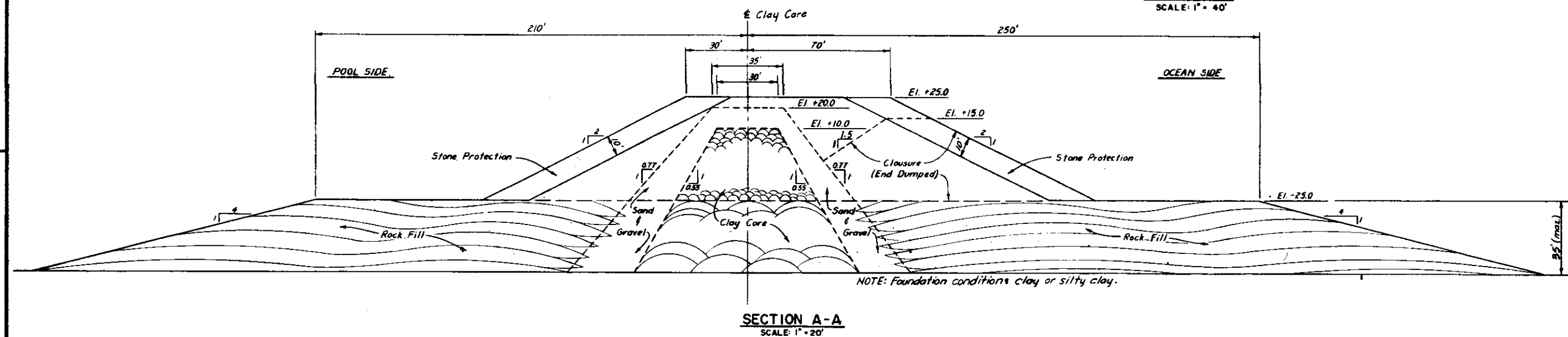
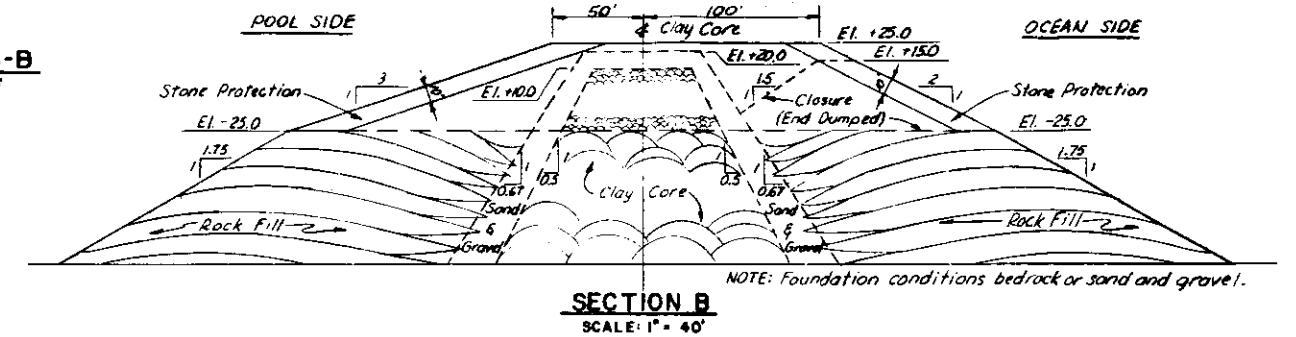
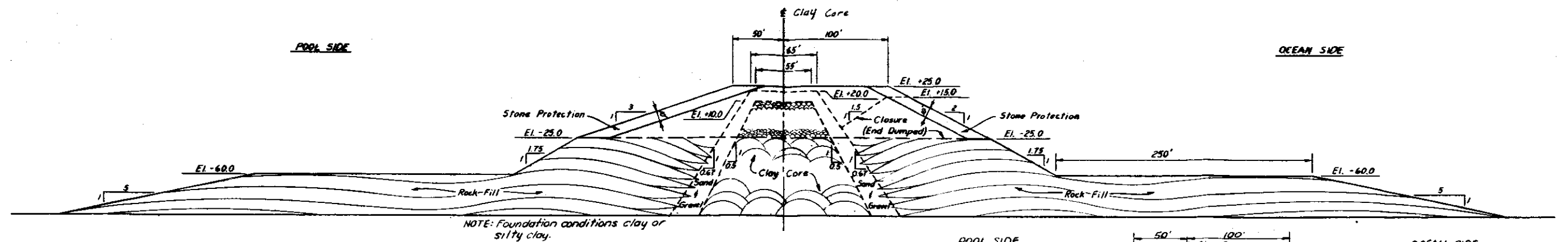
Two solar powered seismic array stations PQ-0 and PQ-1 were established by the Corps of Engineers in 1978 at Cooper Hill and East Ridge School approximately 20 miles west of the project site to monitor seismic activity in the Cobscook Bay region. Since installation there has been no significant activity recorded at the stations which are continuously monitored at the Weston Observatory in Weston, Massachusetts.

#### Embankment Sections

For the purpose of this report, the embankment sections developed for the 1959 International Passamaquoddy Tidal Power Project (reference 15), have been adapted to the conditions for the present Cobscook Bay alignments. These sections (Figure 16), were selected on the basis of practicability of construction and their pool retention capability. Refinement of these sections will be made during later design stages to improve constructibility and economy of materials.

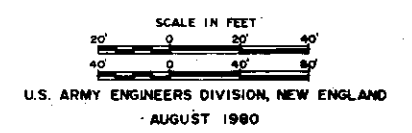
Major considerations associated with embankment design are; selection of appropriate construction materials; determination of suitable disposition of material within the cross-sections of dams; and development of feasible methods of placing material. These basic considerations have both independent and inter-related effects on design and cost of the tidal dams.

One of the first problems in design of the tidal dams for the 1979 study was to determine the best place for the impervious zone of the cross-section. There were two basic approaches to this problem, each with possible variations which could tend to bring the solutions to nearly one design. The first approach included a central core composed of the least pervious material in the entire cross-section located between massive rockfills which provided the structural stability of the dam. The second approach involved the blanket-type design in which the impervious materials



- GENERAL NOTES:
1. All material below El. -25.0 shall be scow dumped.
  2. All material above El. -25.0 (except Closure) shall be bucket-placed.
  3. Closure materials shall be end-dumped.
  4. Refer elevations to Mean Sea Level Datum.
  5. The sections were adopted from the 1959 Passamaquoddy Report, Plate 9-17.

TIDAL POWER STUDY  
COBSCOOK BAY, MAINE  
BIRCH AND GOOSE ALINEMENTS  
TYPICAL SECTIONS



were placed in a relatively thin layer on the higher-water side of a rockfill embankment with only sufficient cover to prevent surface erosion.

For the design conditions of the Passamaquoddy project site, this basic question of where the impervious zone should be located was inseparably associated with the construction procedures involved. Acceptance of a blanket-type impervious zone would permit initial construction of a rockfill embankment to cut off most of the tidal flows, after which the impervious blanket would be added without contending with transverse currents. For construction economy, the initial rock fill embankment on which the impervious blanket would be placed should be constructed with minimum practicable top width and with steep side slopes. The rockfill embankment could be built initially by either scow-dumping or end-dumping operations, or by a combination of these methods. However, such a cross-section of the rockfill portion of the dam would not be used where clay occurs in the foundation area.

The central-core type of construction had the advantage of protecting the impervious materials more completely against erosion, and of using limited quantities of materials more efficiently in the impervious zone. However, the core and rockfill must be placed concurrently.

An adequate dam could be built with the core in either location. In developing a design for cost estimates, it appeared that the central core is better suited to the tidal project than the blanket type particularly for the deep dams and for the dams where clay occurs in the foundation area.

The question of where to place the impervious zone was accompanied by the question of what material to use. The problem was quickly reduced to a choice between a silty clay and a sandy gravel. The clay was better because it provided the greatest resistance to seepage of any of the locally available materials, and enough clay for the impervious zone of the dams would be excavated from the powerhouse headrace (recall that the powerhouse was to be located adjacent to Carrying Place Cove) and wasted if not used in the dams. Proper use of the clay in the tidal dams is largely a matter of setting it in the right place and keeping it there while working in deep water and rapid tidal currents. If the clay is misplaced, it might cause structural weakness in the rockfill portion of the dams.

Sands and gravels are not normally called impervious. For the Quoddy Dams, however, the term is descriptive because the sands and gravels are far more impervious than the adjacent dumped-rock fills. Furthermore, the tremendous quantities of water moving in and out of the pools in normal operation and the low hydraulic head across the massive embankment sections permit use of material that would not be acceptable in the impervious zone of an ordinary dam. Analysis of the hydraulic aspects of placing granular materials in flowing water indicated that discharging from bottom-dump scows should be limited to shallow depths and to essentially uniformly-sized material if a sufficiently impervious zone is to be achieved. Even



with these limitations the materials would tend to scatter widely and much of the finer material would be lost.

After considering all aspects, it appeared that a central core of clay would be most desirable in the tidal design.

After establishment of foundation conditions at the various dam sites, and after investigation of prospective construction materials, design cross-sections were developed on the borrow materials, feasibility of construction procedures and least cost. Structural stability of these embankments, and the foundations on which they would rest, was investigated by the conventional circular arc method of analysis. Analyses were made for various cross-sections applied to generalized foundation conditions representing critical or controlling cases.

#### Construction Materials

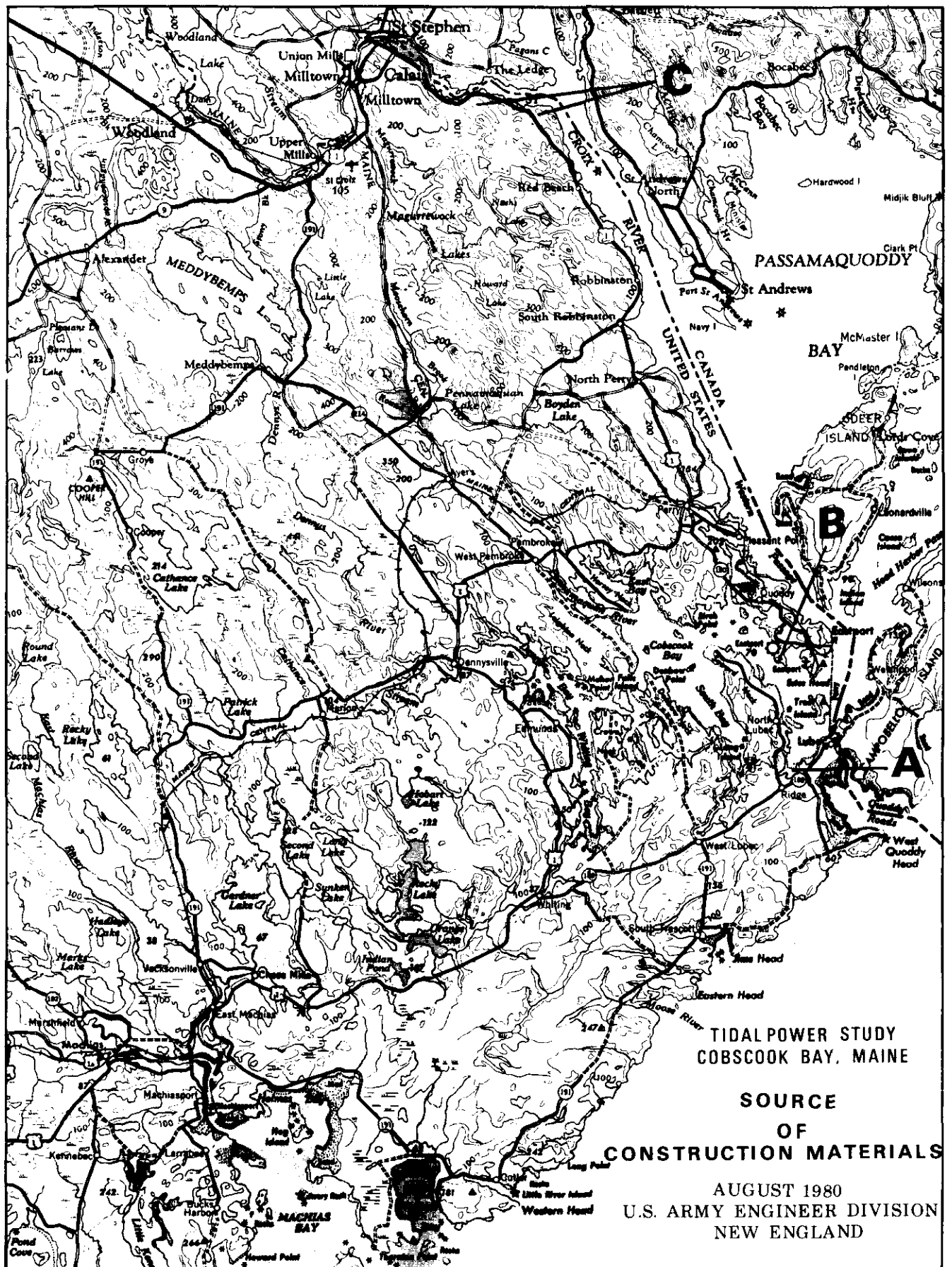
Sources of off-site earth and rock construction materials are available within 25 miles of the project work (Figure 17). Primary sources of earth borrow material investigated for the 1936 construction were from the south and west shores of Johnson Bay. These sources were selected as the only areas adaptable to low-cost excavation by floating equipment and within a short distance of the dam sites (Figure 17, Location A).

Numerous locations were considered as potential quarry sites for stone protection materials and concrete aggregates. Shackford Head on Moose Island was considered the most probable source for concrete aggregate. Utilization of this source will require selective quarrying to separate the desired diabasic rock types from the shale and rhyolitic trap rocks present in the area (Figure 17, Location B).

Two potential sources of rock for sources of protection stone were located by earlier studies in granite formations adjacent to the St. Croix River approximately 25 miles from the project in the vicinity of Devils Head and Elliot Mountain. These areas were selected based on the assumed quality of the granite and their access to water transportation (Figure 17, Location C).

#### Turbogenerating Equipment and Powerhouse

Tidal power plants require low head-high discharge-type turbines capable of operating efficiently under a range of relatively low heads. To accomplish this, costly large size turbines are necessary and the propeller-type unit with variable pitch blades (Kaplan), is normally considered most appropriate. Propeller turbines may be vertical, horizontal or slant mounted and of the tube, bulb or straflo design. Currently, the bulb design, with a horizontal shaft and generator installed in a bulb surrounded by the water passages appears most economical.



The bulb unit assumed for the cost estimates would be rated 15 MW at 13.2' net head and a speed of 56.25 rpm. The diameter of the turbine runner would be approximately 25'. Current information indicates there would be no economic advantage in going to larger size machines. Layout and cost estimates are based on units with adjustable runner blades, adjustable wicket gates and flow in one direction only.

Figure 18 shows a cross-section of a typical powerhouse unit bay. An indoor powerhouse is planned for this bulb unit configuration due to the rigorous climate in Maine.

The deck on the intake side of the powerhouse would be at El. 27, which provides 13.5 ft. of freeboard above the elevation of the maximum operating pool. This is the same freeboard shown in the cross-section of the vertical shaft propeller units proposed in the 1959 Passamaquoddy Study (reference 15), but more than was proposed for the slant axis units in the 1976 study (reference 30).

On the draft tube side of the powerhouse, the roof deck over the indicated electrical and mechanical galleries is shown at El. 34, on the assumption that 3 galleries would be required. However, it may be found, as the powerhouse design is developed in more detail, that only 2 galleries would be needed. In this case, the deck could be lower to El. 27 to match the intake side of the powerhouse.

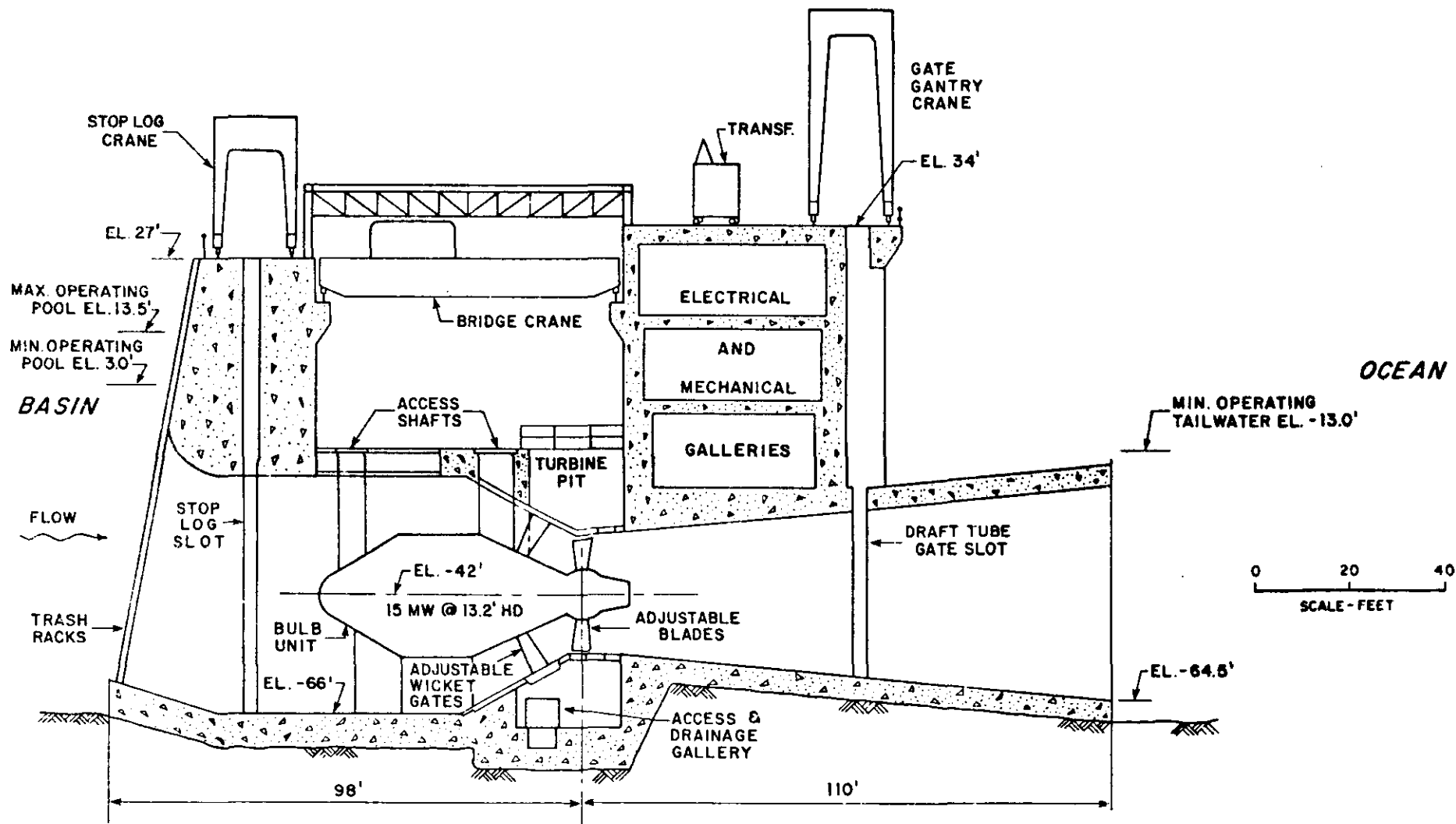
For estimating purposes, it was assumed that each powerhouse unit bay would be 60 ft. wide and constructed as a separate module. When design is developed further, it may appear preferable to construct two-unit modules.

A single service and assembly bay is proposed for each tidal powerhouse. For estimating purposes it has been assumed that it would be 83' wide. The service bay length would match that of the powerhouse unit bay superstructure. The roof would be of reinforced concrete, designed to support trucks and large items of equipment. A stiff leg derrick would be provided for lowering heavy equipment through a large hatch in the roof to the main floor below, where it could be picked up by the powerhouse bridge cranes.

The service bay would include the station sump pumps and unwatering pumps, oil room, air compressors, stair and elevator tower, and space for equipment assembly and maintenance. Also included would be a machine shop, electric shop, locker room, and other service facilities.

Running the full length of the powerhouse and service bay would be two bridge cranes with a combined capacity of 300 tons, which is assumed sufficient to lift the heaviest generator assembly.

Normally, a unit would be shut down by closing the wicket gates, just as on a vertical shaft turbine. However, if the wicket gates should fail to close for any reason, a wheeled gate would be lowered into the draft



**POWER HOUSE CROSS SECTION  
PROPOSED TIDAL PROJECT  
COBSCOOK BAY, MAINE**  
STONE & WEBSTER ENGINEERING CORPORATION  
JANUARY 1979

tube gate slot to stop the flow. A single gate measuring approximately 35' x 35' would be sufficiently large to close off one turbine water passage. A 120 ton capacity draft tube gate gantry crane, as shown on the powerhouse cross-section, would be used to transport each draft tube gate along the powerhouse and to lower it into any one of the unit draft tubes. There would be one draft tube wheeled gate provided for the smaller sized power stations and two for the larger.

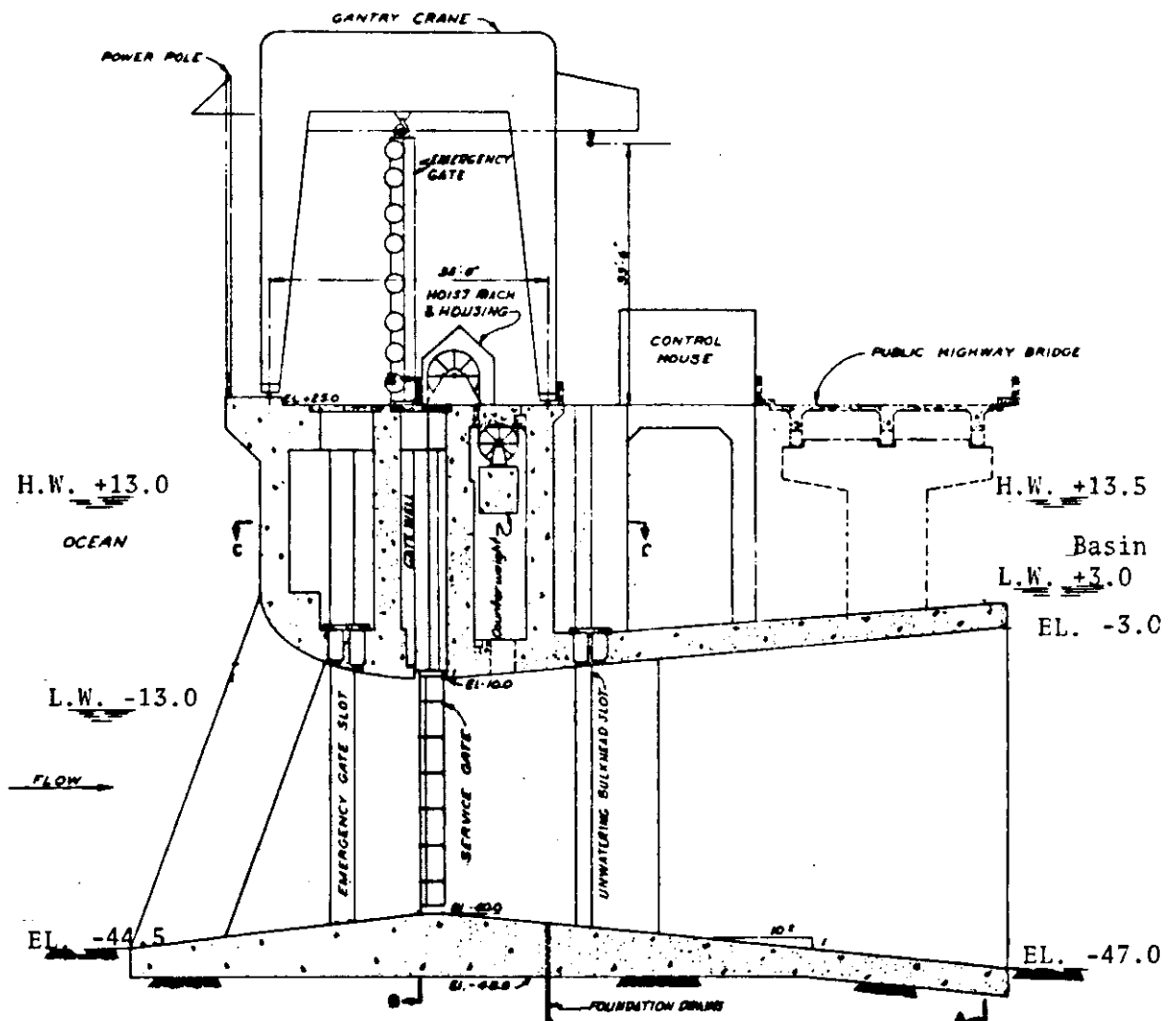
In addition to the wheeled gates, a number of draft tube slide gates could be provided. These would be used only for routine unwatering of the units, when installation would be under balanced head conditions with no flow through the unit. Slide gates are considerably less costly than wheeled gates.

For use in unwatering the units, a number of sets of steel intake stop logs would be provided. A set of six identical stop logs would be required to close off the intakes of one turbine unit. Three stop logs would be stacked in each gate slot on either side of the central pier which divides the intake into two sections. For handling the intake stop logs, there would be a 25 ton capacity gantry crane, as indicated on the drawings of the powerhouse cross-section.

#### Gates

For the "single high pool one-way generation" mode of operation in Cobscook Bay, filling gates would be incorporated into the barrier of the tidal power plant to permit filling the pool on the incoming tide. Since the gates must be opened and closed in accordance with the diurnal tide cycle (705 times annually), they must be capable of rapid, frequent operation and be free as possible of the maintenance and operating problems to assure the reliability of the tidal plant. Earlier detailed studies by Dexter P. Cooper, the International Passamaquoddy Engineering Board, as well as others, have resulted in the selection of the vertical-lift gate, in a submerged venturi setting, as appropriate for tidal power operation. The venturi characteristic of the gate is basically a uniformly expanding discharge section. Model studies of this gate design have demonstrated it to be highly efficient hydraulically. Discharge coefficients ( $C_d$ ) in the orifice equation, of 1.7 were found possible as a result of the venturi section providing "velocity head" recovery. More recently the use of louvered-type flap gated structure has been suggested by others but a hydraulic analysis of this type gate was not made a part of the current studies, and all filling gate studies were based on the hydraulics and costs of standard 30' x 30' vertical lift venturi gate, shown in Figure 19.

The total required filling gate area at any site is a function of the hydraulic capacity of the tidal plant. The volume of water discharged through the turbines during the generating tide must be refilled through the filling gates during the filling tide.



TIDAL POWER STUDY  
COBSCOOK BAY, MAINE

Cross-Section  
Typical Filling Gate  
Structure

U.S. Army Engineer Division  
New England  
FIGURE 19

Siting of the gate structures was accomplished to minimize the amount of excavation (partially rock excavation) while insuring that the foundation of the structure would be rock. This included minimizing the excavation for channels leading to and from the gate structures. Structures will be reinforced concrete. Equipment, including all gates, cranes, and hoisting mechanisms, is as recommended by previous reports (reference 15).

Because tidal power development involves low head-high discharge installation it becomes hydraulically vital that headrace and tailrace losses be kept to a minimum. It is also economically vital that required rock excavation for the headrace and tailrace channels be kept to a minimum in the siting of a tidal power project. Quite detailed studies, performed as part of the original Passamaquoddy work (reference 15), found it economical to maintain average headrace and tailrace velocities at just under 3 feet per second, limiting average hydraulic head losses to about 0.04 foot per thousand feet of channel.

For purpose of establishing minimum excavation requirements in the current studies, maximum headrace and tailrace velocities were set at about 4 feet per second, resulting in a maximum hydraulic loss in the order of 0.07 foot per thousand. The maximum velocities and required excavation were established assuming a minimum operating headrace water level of +3.0 feet NGVD and a minimum tailrace level at -13.0 feet NGVD.

#### Locks

For the purpose of this study a standard lock was adopted for the three alternatives which sealed off large bay areas. The inside dimensions of the lock are 95' long, 25' wide and 12' deep at mean low water. (See Figure 20).

It was assumed that the "floor" of the lock itself would be in excavated rock, i.e., it would not be concrete, and the lock walls would be designed for free draining rock backfill.

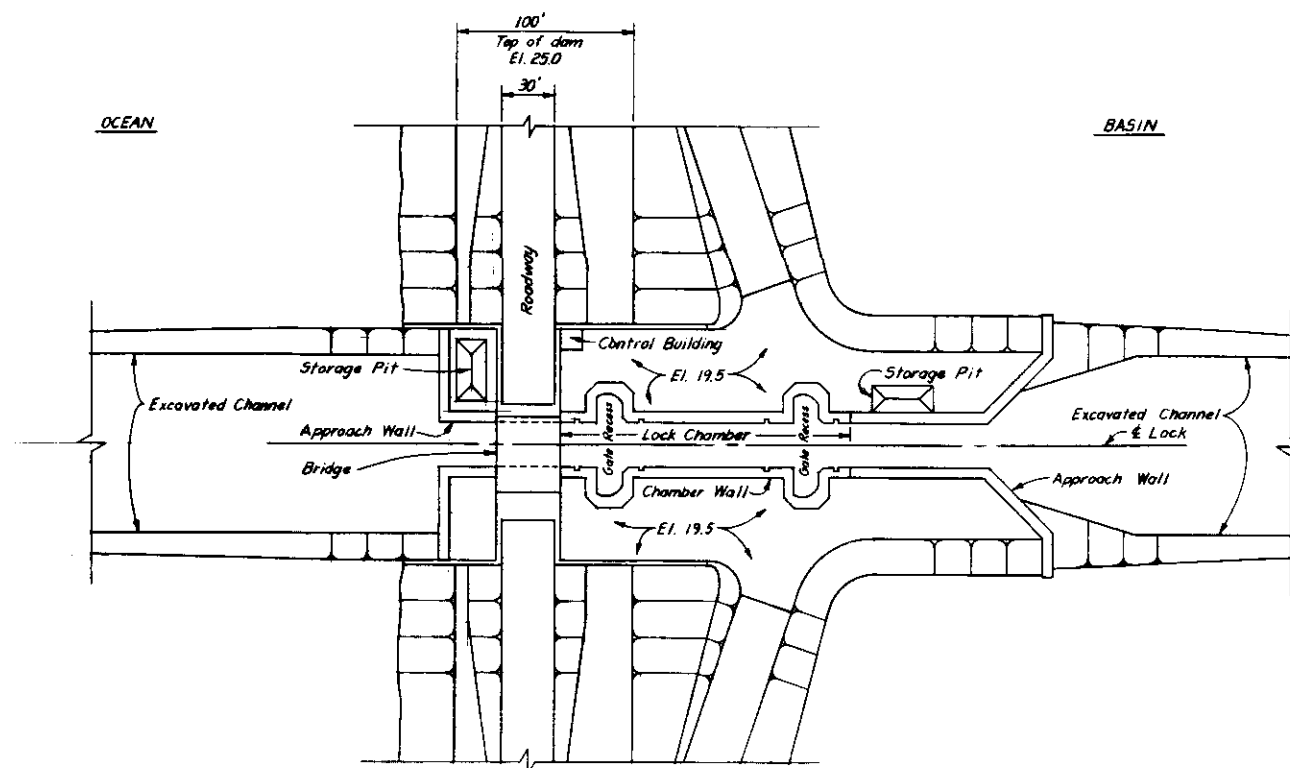
For purpose of this study, it was assumed that, for all alignments and installed capacities, the locks could be located in a rock excavation on or near the shore. Channels 100' wide and 12' below MLW were then excavated through rock and earth from the lock structure to deep water.

#### Other Structures

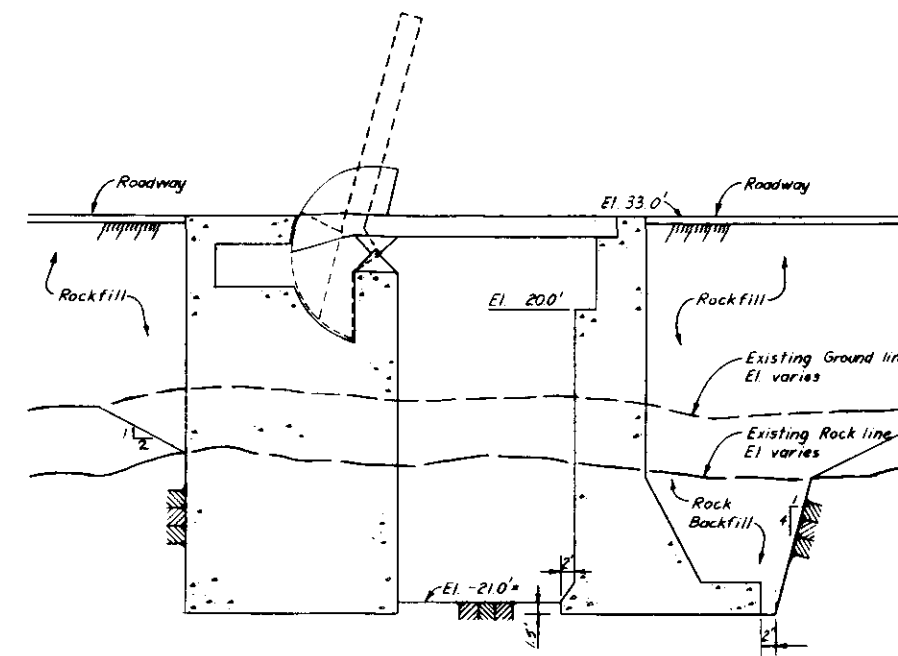
Information on cofferdams can be found in the technical appendix. Fish passages which are a significant feature have not been designed yet, however, for cost estimating purposes a lump sum amount has been assumed.

#### Transmission

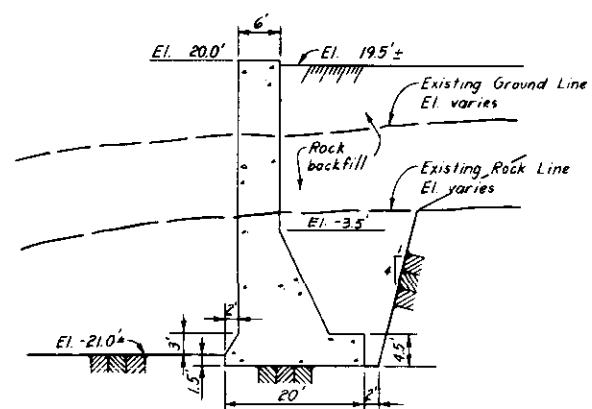
Studies performed by Bonneville Power Administration for the preliminary economic report (reference 33), served as the basis for transmission



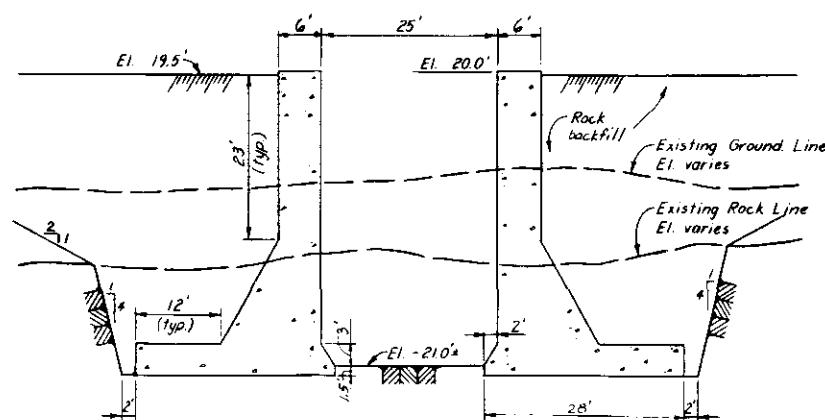
**PLAN**  
SCALE: 1" = 40'



**SECTION ON C OF BRIDGE**  
SCALE: 1" = 10'

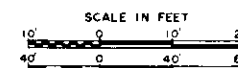


**SECTION THRU APPROACH WALL**  
SCALE: 1" = 10'



**SECTION THRU LOCK CHAMBER**  
SCALE: 1" = 10'

TIDAL POWER STUDY  
COBSCOOK BAY, MAINE  
ALL ALINEMENTS  
LOCK  
PLAN AND SECTIONS



U.S. ARMY ENGINEERS DIVISION, NEW ENGLAND  
AUGUST 1980



data. At that time preliminary design cost estimates for seven alternative transmission plans were derived. Selected designs have been updated for this study

#### Power Estimates

Performance characteristics are normally defined by curves indicating the relation between hydraulic head, discharge, efficiency and power output for the specific turbine speed. For purposes of this study, typical curves, relating head, discharge and generating capacity as a percentage of the rated values were taken from reference 29. Rated generating capacity (nameplate) was computed using a rated head of 10 feet, discharge and adopted 80 percent efficiency in the basic power equation:

$$K = \frac{QHE}{11.8}$$

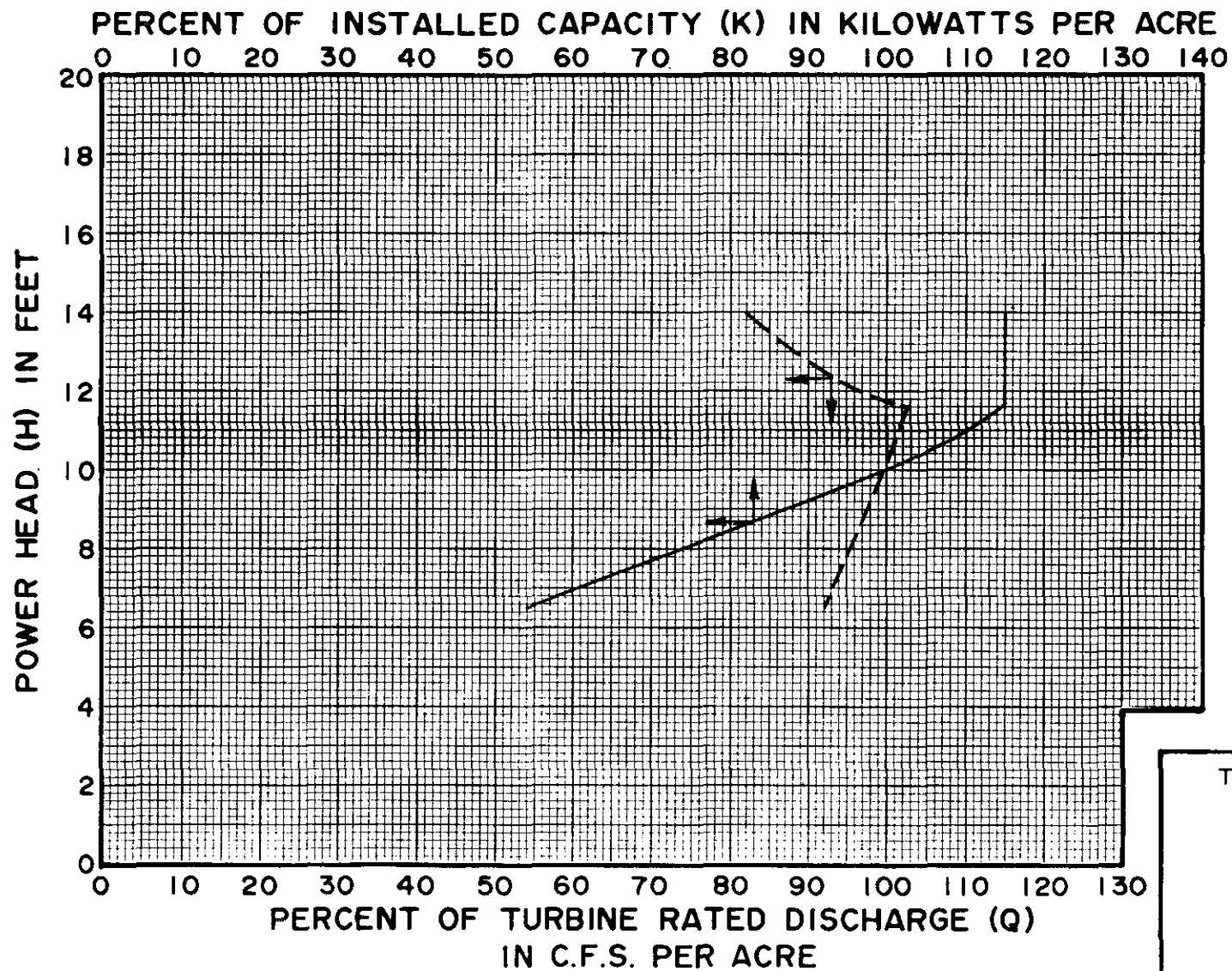
It was further assumed that the system would operate satisfactorily at 15 percent overload.

The variable pitch bladed propeller unit will function efficiently with heads ranging from about 65 to 140 percent of rated head. A rated head of 10 feet was selected permitting generation for heads ranging from 6.5 to 14 feet. The optimum rated head would probably vary with the site and installed capacity, but for relative screening purposes, it was assumed constant for all comparisons.

With the selected rated head, the required discharge capacities were determined for a range of installed capacities in kilowatts power acre of tidal pool area, using the basic power equation. Once the turbine capacities were determined, the adopted performance curves were used to determine the turbine characteristics at head relative to the rated head. The typical unit characteristic demonstrates the operation flexibility of the unit plus the restraints of the 15 percent overload limitation. It is known that when maximum output is being developed (15 percent overload) and head is sufficient, then flow is cut back to prevent excessive overload and possible damage to the generator. When heads are below the minimum of 6.5 feet, it was assumed that no power would be generated and when heads are greater than 11.5 feet, flow will decrease with power output holding constant at 15 percent overload. Studies to determine the feasibility of using oversized generators should be made a part of any final design effort. Table 17 lists quantitative values used in the development of the performance curve shown on Figure 21.

TABLE 17  
TURBINE PERFORMANCE CHARACTERISTICS

Installed Capacity Head (feet)	7 KW/AC		14 KW/AC		28 KW/AC		42 KW/AC	
	Flow cfs/ac	Power kw/ac	Flow cfs/ac	Power kw/ac	Flow cfs/ac	Power kw/ac	Flow cfs/ac	Power kw/ac
14	8.4	1.8	16.8	16.1	33.6	32.2	50.4	48.6
13	9.1	8.1	18.2	16.1	36.4	32.2	54.6	48.6
12	9.8	8.1	19.6	16.1	39.2	32.2	58.8	48.6
11	10.5	7.7	21.0	15.4	42.0	30.8	63.0	46.2
Rated 10	10.3	7.0	20.6	14.0	41.2	28.0	61.8	42.0
9	10.0	5.8	20.0	11.6	40.0	23.2	60.0	34.8
8	9.8	5.1	19.6	10.2	39.2	20.4	58.8	30.6
6.5	9.4	3.9	18.8	7.8	37.6	15.6	56.4	23.4



UNIT CHARACTERISTIC  
CURVES BASED ON A  
RATED HEAD OF 10 FEET.

$$K = \frac{QHE}{11.8}$$

TIDAL POWER DEVELOPMENT

COBSCOOK BAY

TYPICAL UNIT  
CHARACTERISTICS

APRIL 1980

MAINE

FIGURE 21

The economic benefits of any tidal power project are a function of the average annual energy that can be produced. For the Cobscook Bay sites the annual energy per unit pool area was estimated by performing manual step routings for various selected installed capacities in order to simulate the power operation. These routings were cursory in nature and were applied through the average tidal range of 18.2 feet for the selected rated capacities of 7, 14, 28 and 42 kilowatts per acre of tidal pool area. It should be noted that these routings do not present the refinement of optimization that could only be accomplished through detailed computer simulation studies; however, they are considered appropriate for purposes of site screening.

Capacity and energy relationships have been derived assuming a 10-foot rated head. However, powerhouse and turbogenerators have been designed assuming a 13-foot rated head. In future studies an optimum rated head will be identified and utilized. Adjustments have been made in capacity energy relationships to reflect the differences in selected rated heads. For example an 10 MW unit at a rated head of 10 feet would be comparable in size and energy production to a 13 MW unit at a rated head of 13 feet.

As mentioned previously, for single high pool plans, power is generated during the period when the ocean level is lower than the pool level by discharging water through turbines from the pool to the ocean. In an effort to maximize energy, the times at which generation begins for each of the selected rated capacities were derived by trial in order to determine best relationships between head, discharge and generation time resulting in the maximum production of energy.

As previously stated, the minimum head at which power could be satisfactorily generated was 6.5 feet. This minimum head requirement was a governing factor in establishing generation time for many of the installations. As shown on Figure 22, all operating schemes end generation at this minimum head of 6.5 feet. The heads at which operation begins is, however, flexible, and is dependent on the interrelationships between head and discharge capacity throughout the routing period resulting in the production of maximum energy. This is evidenced on Figure 22 by observing the relative delayed starting times with the larger installed capacity. Since the hydraulic capacities of the 28 and 42 kw/acre installed capacities, are relatively large (increased pool drawdown), the starting times of generation were delayed such that maximum heads would be available. The rated capacities of 7, 14, 28 and 42 kw/acre, permitted approximately 345, 300, 180 and 135 minutes of generation per mean tide cycle, respectively.

It is also noted, as shown on Figure 22 that there is about a one foot differential between initial pool level and high tide level because of the inability to completely fill the pool to high tide by gravity.

With the relationship of head, discharge and generating times developed from the routines, the relationships of rated capacity, energy per tide cycle and plant factor (capacity factor), were developed as shown

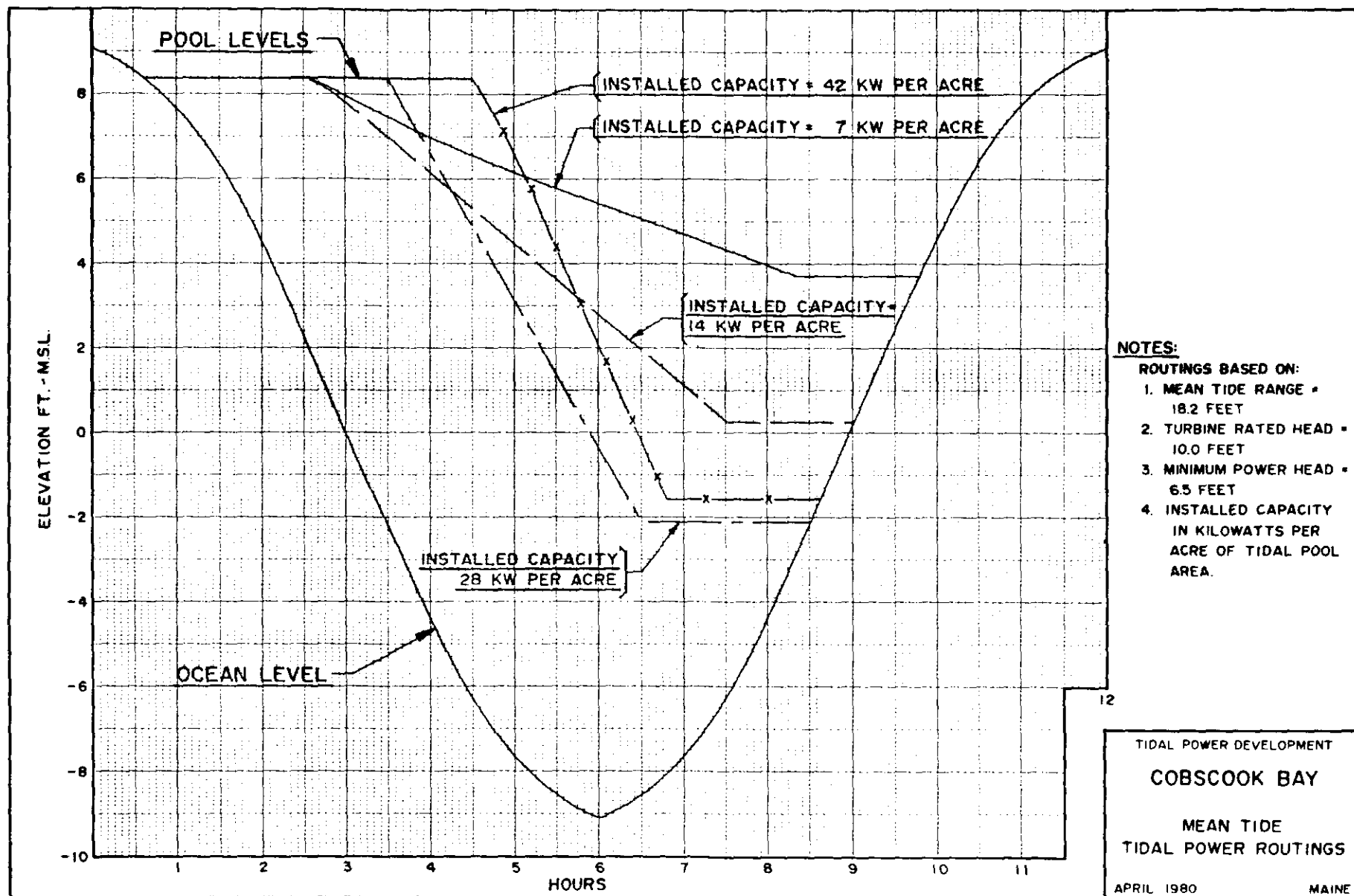


FIGURE 22

on Figure 23. As the curves on this plate demonstrate, energy increases with increasing installed capacity but at the decreasing rate. It can be seen that the energy produced is intermittent regardless of the installed capacity and that the smaller installed capacities, while producing less energy, have the benefit of longer generating times relative to the larger installed capacities which have the advantage of producing more energy but with shorter generating times.

The routings and energy developed are considered representative for mean tide cycle, however, more flexible operating procedures could result during an outgoing tide by varying the start of generation thereby varying the resulting capacity and energy output depending on the anticipated power demand.

From the graphical routings on Figure 22, the generation and filling times can be determined. It is seen that the required rate of flow through the gates is proportional to the rate of flow through the turbines, by the ratio of their respective generating times. For example: for an installed capacity of 14 kw/acre, from Figure 22 it is observed that three-fifths as much time is available for filling as for generating, and therefore, the gate capacity must be one and two-thirds times greater than the turbine capacity. With the hydraulic capacity (Q) of the gate known, the gate area (A) required to pass this flow is determined from the "orifice" equation.

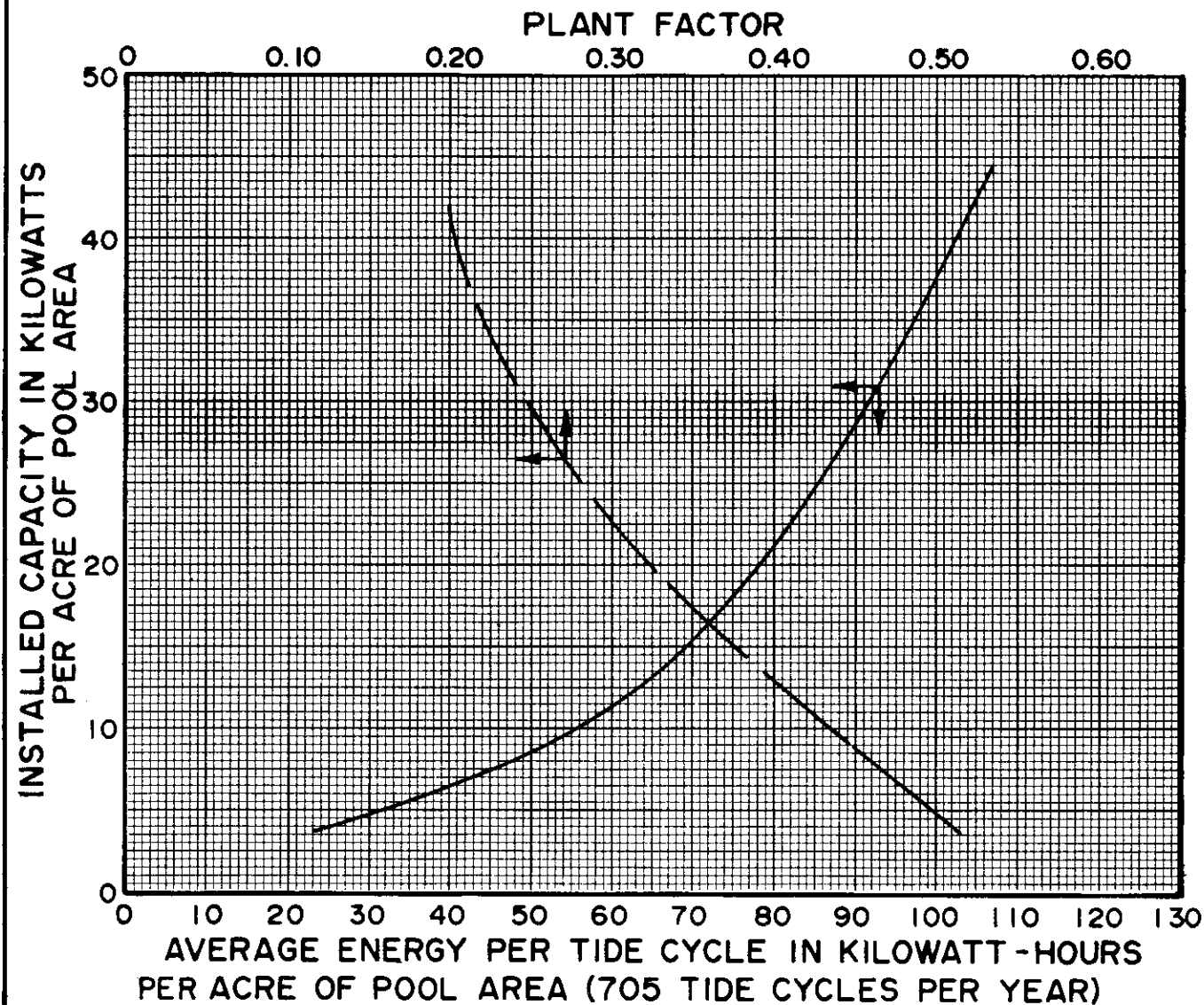
$$Q = C_d A \sqrt{2gh}$$

where  $C_d$  = coefficient of discharge of the gate. From previous model studied by the Corps, the average coefficient of discharge for the venturi gate under normal operating conditions was determined to be approximately 1.7. This relatively high coefficient is attributable to the submerged "venturi" expansion of the gate and its effectiveness in regaining the velocity head of the discharge.

$h$  = average head differential between the ocean and the pool during filling operations. The head differential varies during the fill period but it was assumed that the average for the period would not exceed 2 feet. With a 20-foot head differential, velocities through the gate opening would be in the order of 20 ft/sec. The relationship between required gate area and installed capacity per acre of pool area is graphically presented as Figure 24.

#### Cost Estimates

Estimates of costs for the tidal project are presented in this section. Initially cursory conservative cost estimates of powerhouse, gates, dams, cofferdams, excavation and locks were prepared for each of the four alternatives under study, assuming four different installed capacities for each alternative - 16 estimates.



CURVES BASED ON:

1. MEAN TIDE RANGE = 18.2 FEET
2. TURBINE RATED HEAD = 10.0 FEET
3. MINIMUM POWER HEAD = 6.5 FEET

TIDAL POWER DEVELOPMENT

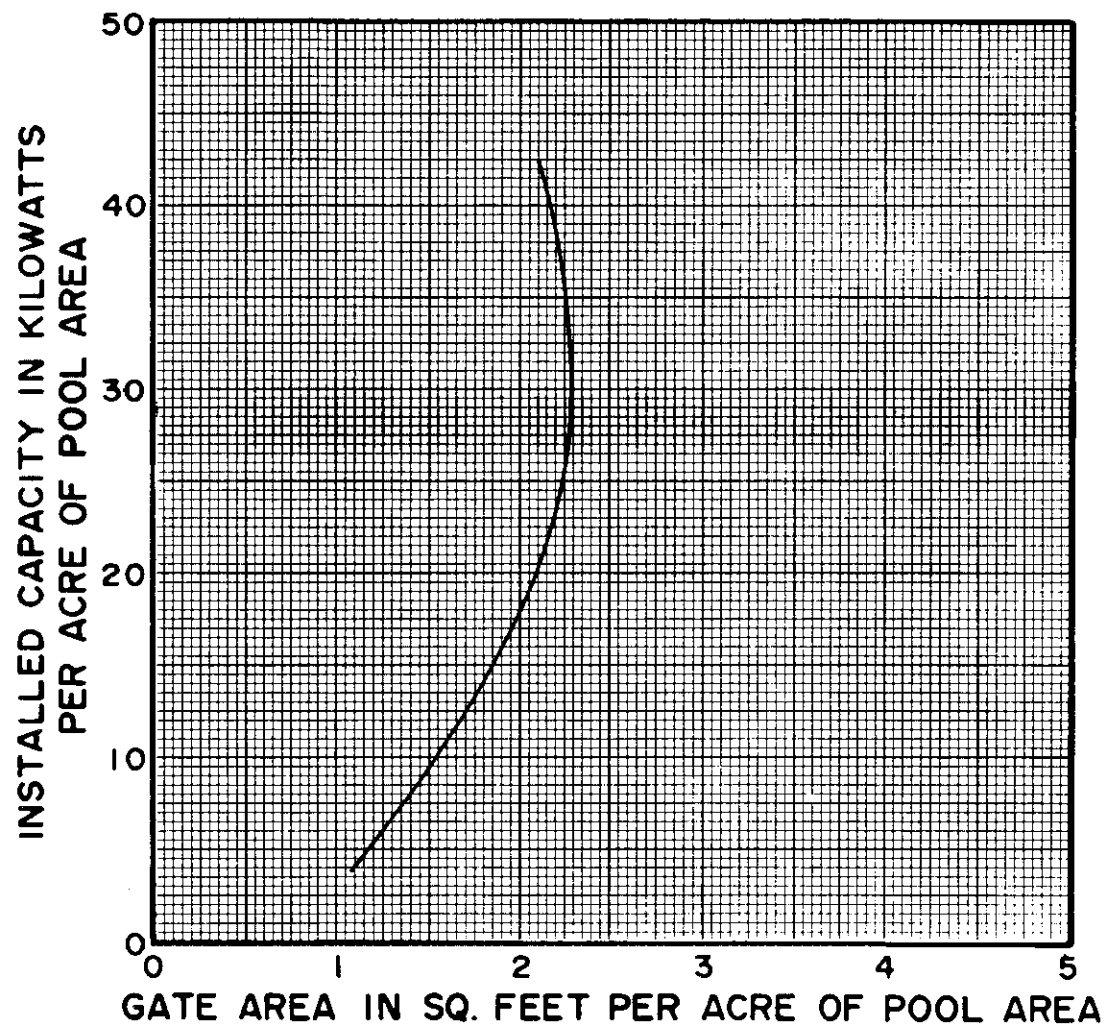
**COBSCOOK BAY**

CAPACITY VS ENERGY  
AND PLANT FACTOR

APRIL 1980

MAINE

FIGURE 23



CURVE BASED ON:

1. MEAN TIDE RANGE = 18.2 FEET
2. TURBINE RATED HEAD = 10.0 FEET

TIDAL POWER DEVELOPMENT

**COBSCOOK BAY**

INSTALLED CAPACITY  
VS.  
FILLING GATE AREA

APRIL 1980

MAINE

FIGURE 24



Pertinent data for that brief analysis is presented in Table 18 below.

Table 18  
Initial Cost Estimate Results

<u>Alternative</u>	<u>Capacity MW</u>	<u>Energy GWH</u>	<u>Capacity Factor</u>	<u>Cost \$/KW (Dec. 1979)</u>
Dudley	120-970	470-1,420	15-50	1600-3,300
Goose	100-815	400-1,215	15-50	2100-3,500
Birch	80-700	340-1,040	15-50	1900-3,500
Wilson	18-150	70-222	15-50	3600-10,000

The data derived tended to reinforce the earlier findings (reference 33), that projects designed to operate at annual capacity factor around 40% (Q<sub>4</sub>) provided lowest cost energy. Based on the results shown in Table 18 above it was decided to refine estimates for selected alternatives designed to operate at annual capacity factors of about 40%. Owing to the high costs associated with the Wilson alternative (2-3 times greater than other alternatives) and also to its limited hydroelectric potential compared to other alternatives it was decided to delete this alternative from further economic analysis.

It was also decided that the Dudley alternative would not be analyzed further for this study. The Dudley alternative was deleted because at this time it appears to have more possible potential problems in terms of construction than do the Birch and Goose alternatives.

If studies of Cobscook Bay continue more rigorous analysis may be undertaken for the Dudley and Wilson alternatives.

Refined cost estimates were prepared for both the Goose and Birch alternatives. Elements included were gates, powerhouses, turbogenerators, dams, locks, cofferdams and excavation. Table 19 presents data from these estimates.

Table 19  
Refined Cost Estimates  
(July 1979 price level)

<u>Alternative</u>	<u>Capacity MW</u>	<u>Energy GWH</u>	<u>Capacity Factor</u>	<u>\$/KW</u>	<u>Mills/kwh</u>
Birch	105	401	45	2874	54
Birch	165	560	40	2487	52
Birch	225	650	35	2403	59
Goose	135	500	45	2561	49
Goose	195	660	40	2291	48
Goose	225	760	35	2044	49

Based on the results present in Table 19 above, complete estimates were prepared for the following alternatives:

Goose Alternative - 195 MW

Birch Alternative - 165 MW

Pertinent data describing these alternatives are shown on Table 20 and Preliminary project layouts and profiles are shown as Figures 25 through 28. Project Estimates are presented in Table 21.

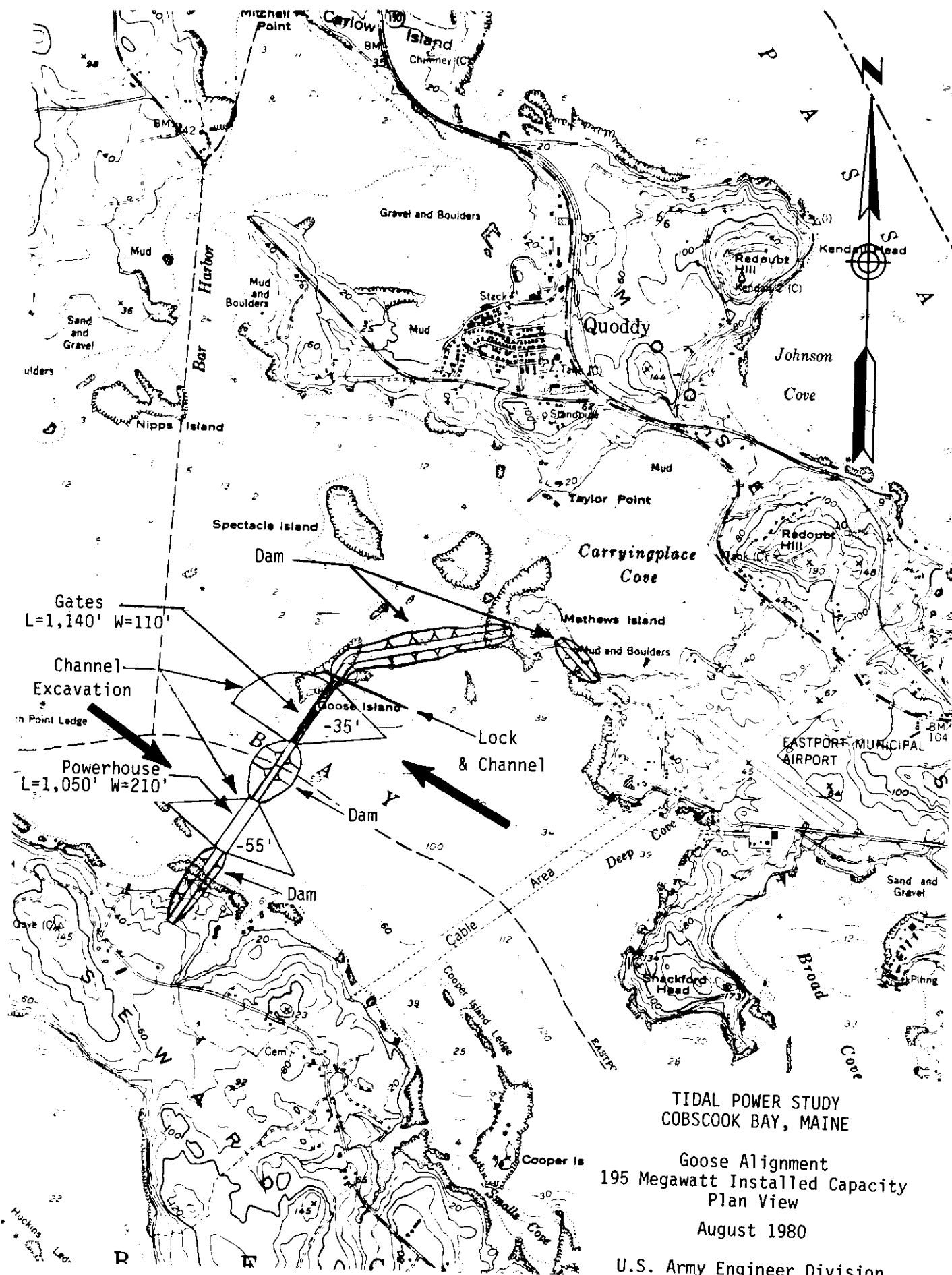
Table 20  
Pertinent Data Goose and Birch Alignments

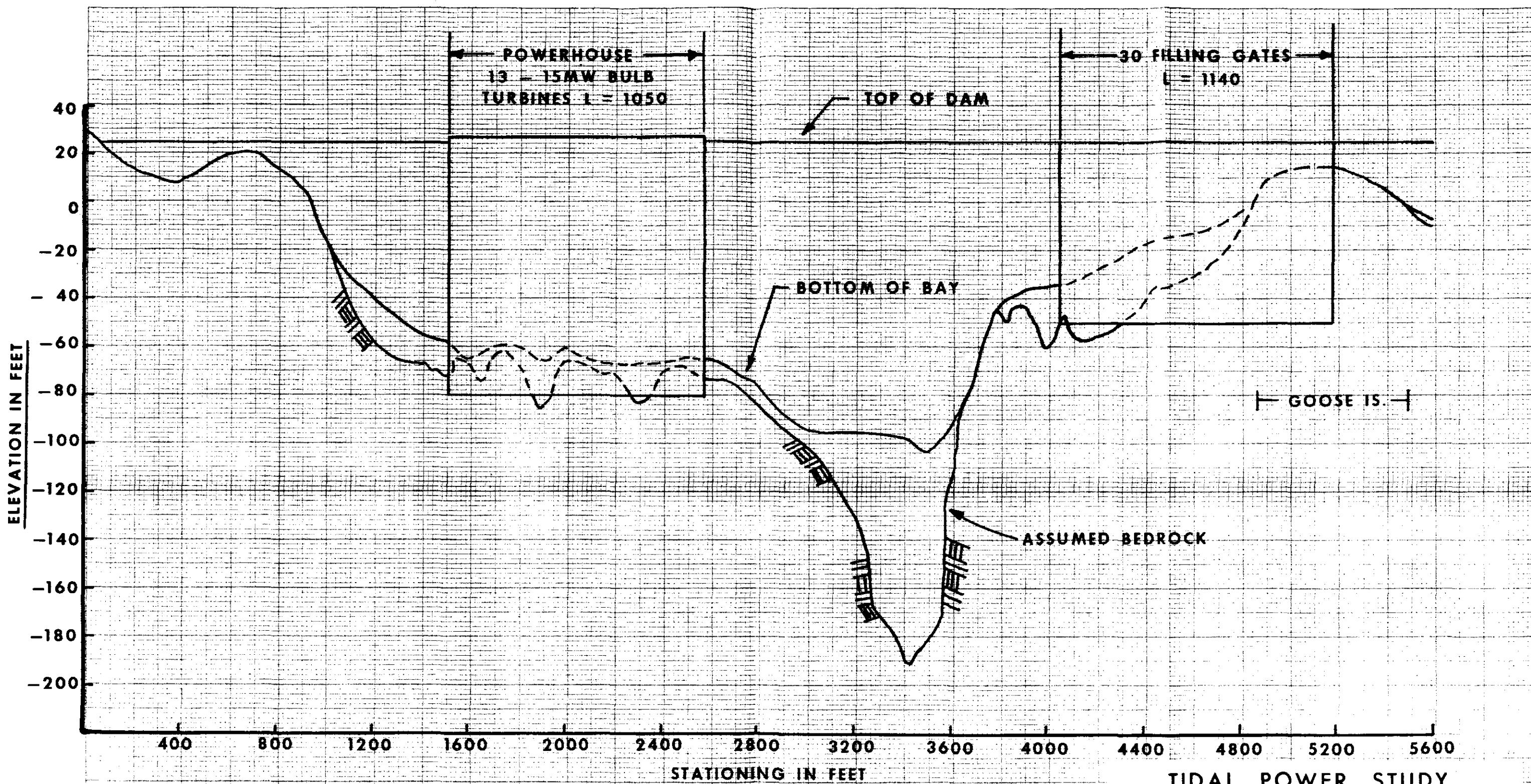
<u>TOTAL PROJECT:</u>	<u>GOOSE - 195</u>	<u>BIRCH - 165</u>
Length	8,100'+	5,100'+
Top Elevation	+25.0'	+25.0'
Datum	Mean Sea Level	Mean Sea Level
Excavation	990,000 cy	375,000 cy
Fill	5,700,000 cy	3 450,000 cy
<u>POWERHOUSE:</u>		
Length (total*)	1 050'	890'
Installed Capacity	195 MW	165 MW
No. of Units	13	11
length of units	780'	660'
width/unit	210'	210'
Turbine (units)		
type	Horizontal Bulb	Horizontal Bulb
capacity	15 MW	15 MW
rated head	13.2	13.2
center line of unit	E1. -42.0'	E1. -42.0'
Max. Operating Pool	E1. +13.5'	E1. +13.5'
Min. Operating Pool	E1. +3.0'	E1. +3.0'
Min. Tailwater	E1. -13.0'	E1. -13.0'
Structural Excavation	65,000 cy	25,000 cy
Channel Excavation	300 000 cy	255,000 cy
<u>GATES:</u>		
Length (total)	1 140'	990'
No. required	30	26
Type	Vertical Lift	Vertical Lift
	(submerged venturi)	(submerged venturi)
Invert	E1. -40.0'	E1. - 40.0'
Structural Excavation	50,000 cy	10 000 cy
Channel Excavation	570,000 cy	90,000 cy

Table 20  
Pertinent Data Goose and Birch Alignments (Cont.)

	<u>GOOSE - 195</u>	<u>BIRCH - 165</u>
<u>DAM:</u>		
Length (overall)	5,800'+	4,000'+
Top Elevation	+25.0'	+25.0'
Top Width	Varies (100' min. to 150' max.)	Varies (100' min. to 150' max.)
Maximum Height	130'+	120'+
Fill		
stone protection	480,000 cy	190,000 cy
rockfill	3,750,000 cy	2,500,000 cy
sand and gravel	600,000 cy	260,000 cy
clay core	900,000 cy	550,000 cy
<u>LOCK:</u>		
Length (inside)	95'	95'
Width (inside)	25'	25'
Min. Depth (@ Mean Low Water)	12'	12'
Top	E1. +20.0'	E1. +20.0'
Invert	E1. -21.0'	E1. -21.0'
<u>COFFERDAMS:</u>		
Length	7,200'+	5,300'+
Max. Height	85'+	100'+
Top Elevation		
earthen embankment	+20.0'	+20.0'
timber or steel sheeting	+18.0'	+18.0'

\*Includes mass concrete separating the units.





NOTES:  
 "BOTTOM OF BAY" AND "ASSUMED BEDROCK" BASED ON SEISMIC SURVEY  
 PERFORMED IN JUNE 1977

TOP OF GATES AND DAM AT EL. +25  
 TOP OF POWERHOUSE DECK AT EL. +27

DATUM IS THE NATIONAL GEODETIC VERTICAL DATUM (NGVD)

SCALE

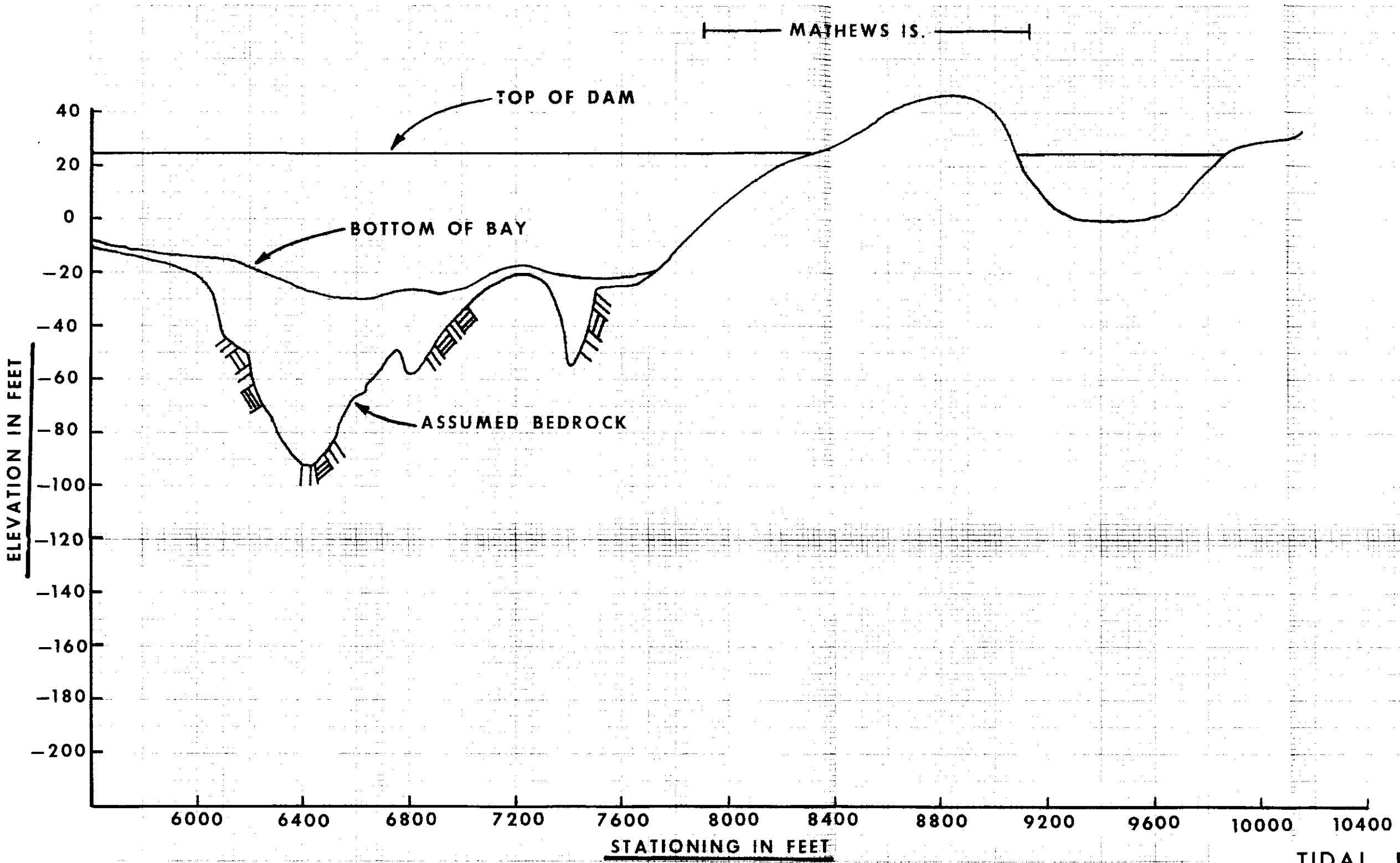
VERT. 1 in. = 400 ft.  
 HORIZ. 1 in. = 40 ft.

TIDAL POWER STUDY  
 COBSCOOK BAY, MAINE

GOOSE ALIGNMENT  
 PROFILE

AUGUST 1980

ARMY ENGINEER DIVISION, NEW ENGLAND



**NOTES:**

"BOTTOM OF BAY" AND "ASSUMED BEDROCK" BASED ON SEISMIC SURVEY PERFORMED IN JUNE 1977

TOP OF GATES AND DAM AT EL. +25  
TOP OF POWERHOUSE DECK AT EL. +27

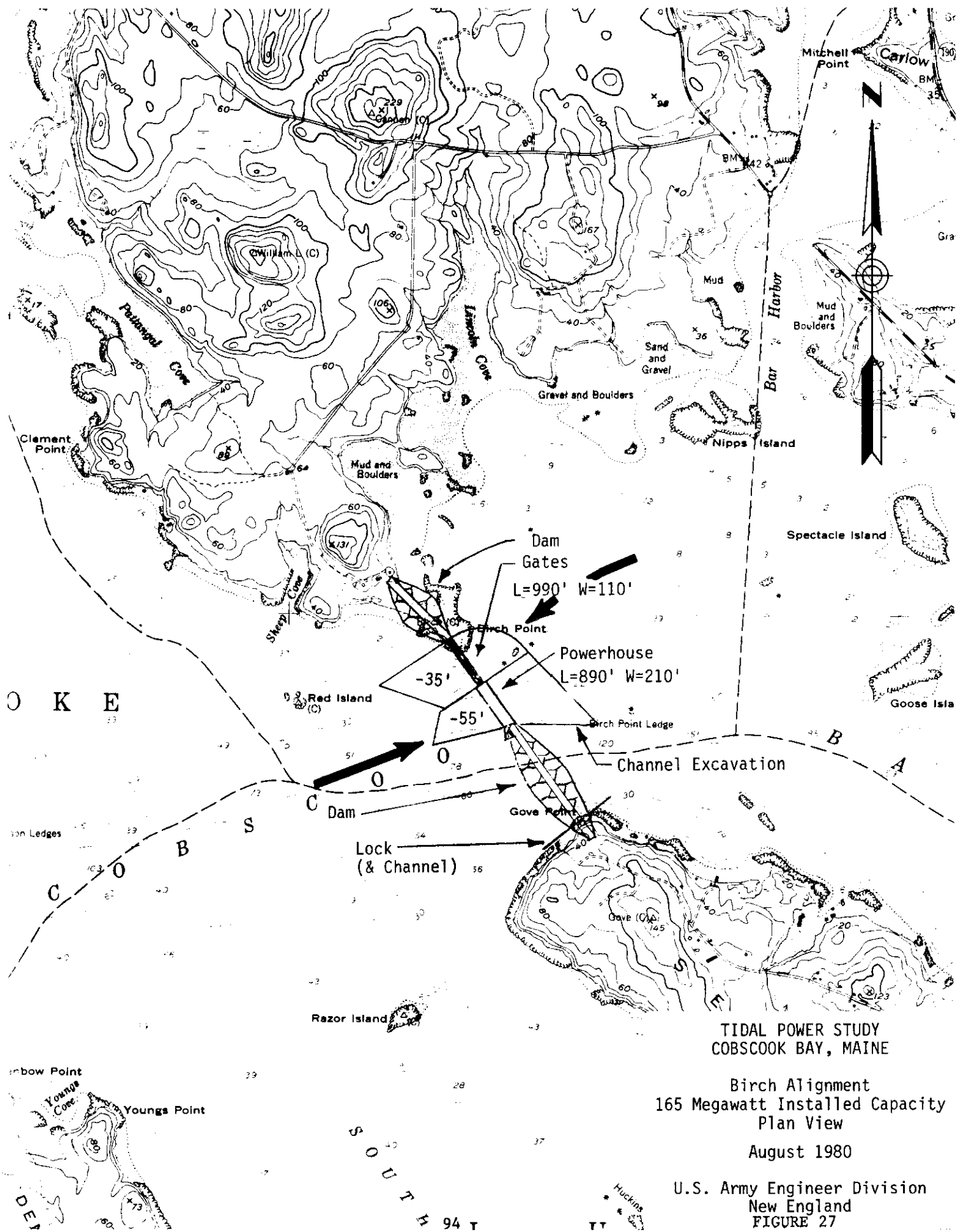
DATUM IS THE NATIONAL GEODETIC VERTICAL DATUM (NGVD)

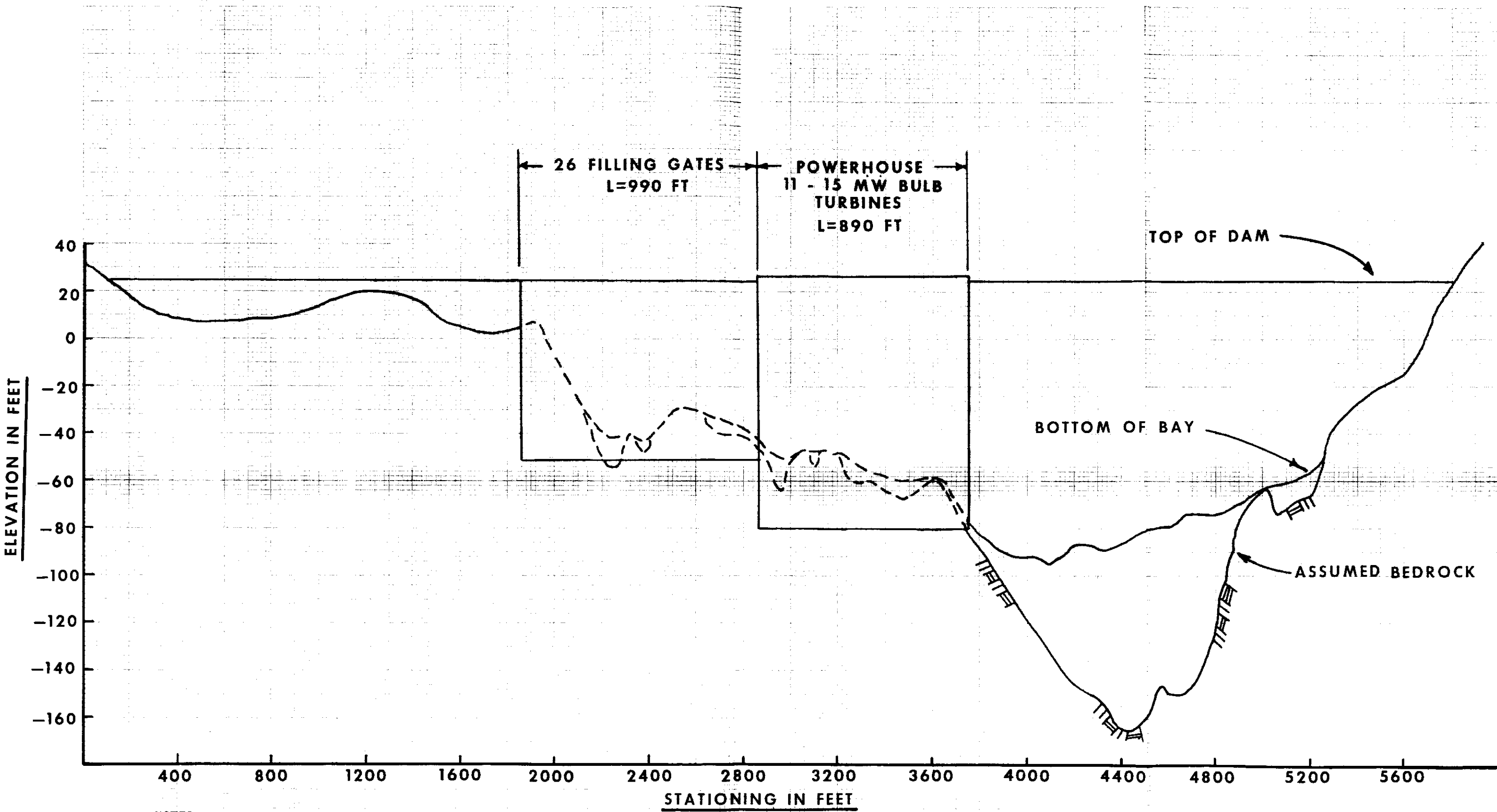
**SCALE**

VERT. 1 in. = 400 ft.  
HORIZ. 1 in. = 40 ft.

**TIDAL POWER STUDY  
COBSCOOK BAY, MAINE  
GOOSE ALIGNMENT  
PROFILE**

AUGUST 1980  
ARMY ENGINEER DIVISION, NEW ENGLAND





**NOTES:**

"BOTTOM OF BAY" AND "ASSUMED BEDROCK" BASED ON SEISMIC SURVEY PERFORMED IN JUNE 1977

TOP OF GATES AND DAM AT EL. +25  
 TOP OF POWERHOUSE DECK AT EL. +27

DATUM IS THE NATIONAL GEODETIC VERTICAL DATUM (NGVD)

**SCALE**

VERT. 1 in. = 400 ft.  
 HORIZ. 1 in. = 40 ft

**TIDAL POWER STUDY  
 COBSCOOK BAY , MAINE  
 BIRCH ALIGNMENT  
 PROFILE**

AUGUST 1980  
 ARMY ENGINEER DIVISION, NEW ENGLAND



Table 21  
Cobscook Bay Project Cost Estimate

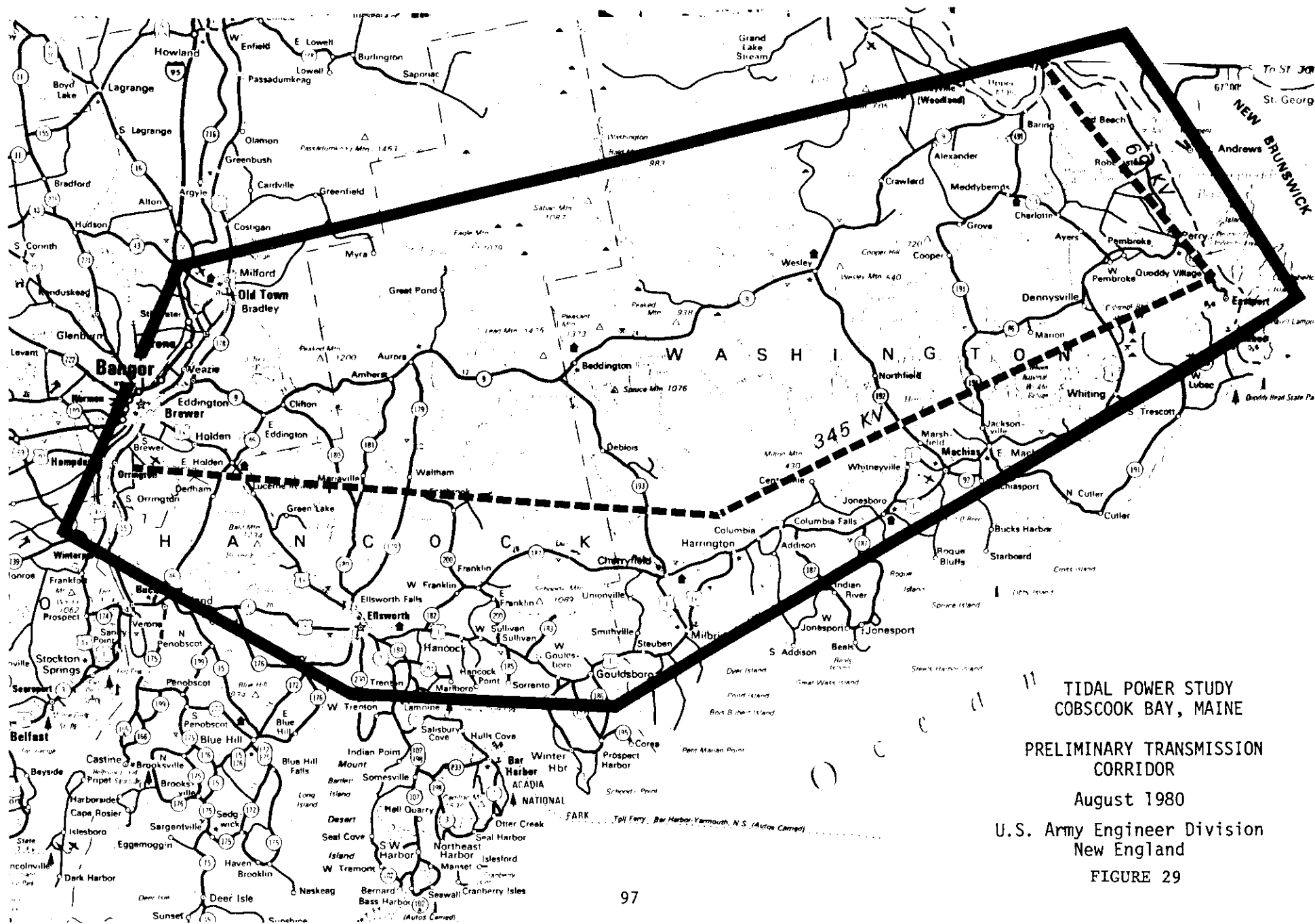
Alternative Installed Capacity Average Annual Energy	Goose Alignment 195 MW 660 GWH	Birch Alignment 165 MW 560 GWH
Dams	60,100,000	36,200,000
Navigation locks	14,500,000	13,700,000
Sluice Gates	82,200,000	70,300,000
Powerhouse	274,000,000	286,400,000
Cofferdams	56,300,000	41,400,000
Service Facilities	1,400,000	1,200,000
Relocations	1,000,000	1,000,000
Fishways	2,000,000	2,000,000
Subtotal	491,500,000	452,200,000
Contingency - 15%	73,700,000	67,800,000
Subtotal	565,200,000	520,000,000
E & D and S & A - 10%	56,500,000	52,000,000
Subtotal	621,700,000	572,000,000
Real Estate Inc. 20% ctg.	1,000,000	1,000,000
Service Equipment	600,000	600,000
Project Cost	623,300,000	573,600,000
Construction Time (years)	5	5
Interest During Construction	111,000,000	102,200,000
Project Life (years)	100	100
Interest and Amortization	52,400,000	48,200,000
Operations & Maintenance	1,400,000	1,200,000
Major Replacement	600,000	500,000
Annual Cost	54,400,000	49,900,000
Cost of Energy mills/kwh	83	90
Cost Per Kilowatt \$/kw	3,765	4,094

Computation based on 7-1/8% interest rate, August 1980 price levels.

For this report Bonneville Power Administration prepared a preliminary transmission design and estimate for a hypothetical 200 MW tidal power project. Figure 29 shows the preliminary transmission corridor.

For generating capacity of 200 MW, the integrating transmission will most likely be either 230-kV or 345-kV. The investment cost of a 345-kV system is comparable to that of a 230-kV system. The 230-kV alternative has lower line costs but greater substation costs. Since transmission losses would be lower for 345-kV, a 345-kV system has been assumed in developing the cost estimates. Peak losses are in the order of 1.5% for a 345-kV system and 4.0% for a 230-kV systems. For the 345-kV system energy losses resulting from transmission are less than 1.0%.

A 345-kV system will also have the advantage of not introducing a new voltage level into the area (115-kV and 345-kV be in the existing voltage



TIDAL POWER STUDY  
COBSCOOK BAY, MAINE

PRELIMINARY TRANSMISSION  
CORRIDOR

August 1980

U.S. Army Engineer Division  
New England

FIGURE 29

levels). A sketch of the integrating transmission system is shown as Figure 30. The system includes a 69-kV line from the project to Calais.

Facilities for transformation at Epping have not been included because the need for such facilities have not been thoroughly investigated. However, the addition of a 345/115-kV transformer bank at Epping would improve the reliability of service to that area. A cost estimate of the preliminary plan is shown in Table 22.

Table 22  
Cobscook Bay Tidal Power Project  
Cost Estimates - Transmission Facilities  
(7-1/8% Interest Rate)

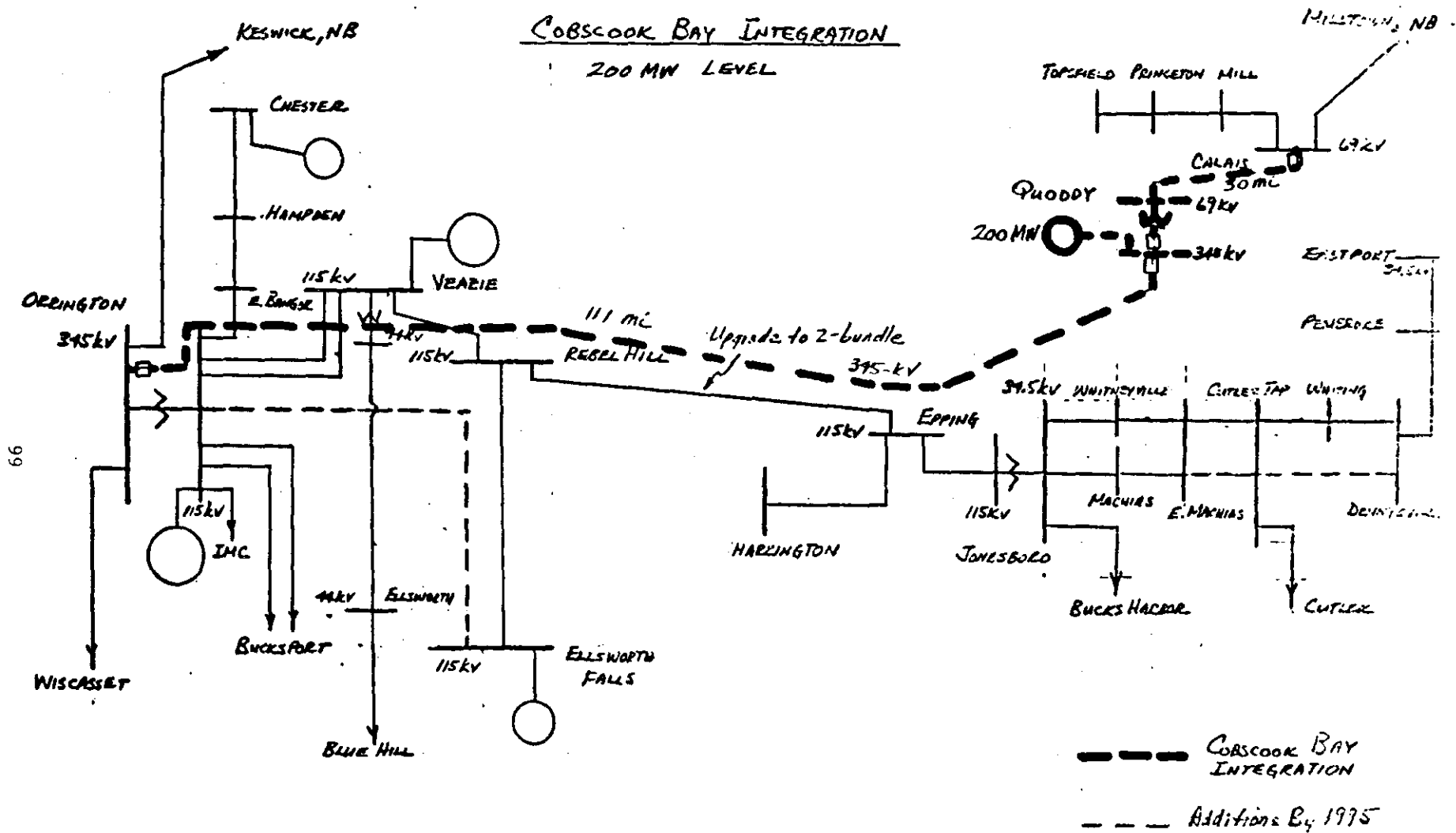
Lines	Investment (\$000)			Annual Cost (\$000)		
	Construction	IDC	Total	I&A	O&M	Total
Quoddy - Orrington						
345-kV WHF (11 miles)	20,000	3,340	23,340	1,790	200	1,990
Quoddy - Calais						
69-kV WHF (30 miles)	4,000	670	4,670	360	40	400
Subtotal	24,000	4,010	28,010	2,150	240	2,390
Substation Facilities						
Quoddy - 345/69 kV Transformer	3,100	502	3,620	300	40	340
2-345-kV PCB's	1,500	250	1,750	150	50	200
Calais - 69-kV PCB	150	30	180	20	10	30
Carrington - 2-345-kV PCB's	1,500	250	1,750	150	50	200
Subtotal	6,250	1,050	7,300	6,120	150	770
Power System Control	1,000	170	1,170	110	50	160
TOTAL	31,250	5,230	36,480	2,880	440	3,320

Note: Service Life: Lines (WHF) 38 years  
                          Substation 28 years  
                          PSC 20 years

Replacements have been included in the calculation of annual costs

IDC @ 7-1/8% interest: 16.7% of construction cost

Table 23 shown below present the approximate total investment and annual costs associated with a 165 MW tidal power project at Birch Point and also for a 195 MW tidal power project at Goose Island assuming an 100-year project life, 7-1/8 percent interest and August 1980 price levels. Costs for the 200 MW transmission plan have been used for both alternatives.



BANGOR HYDRO-ELECTRIC SYSTEM TO EASTPORT

FIGURE 30  
RBP  
3-5-80

Table 23  
Cost of Two Possible Tidal  
Power Projects Including Transmission (\$000)

<u>Alternative</u>	<u>Installed Capacity MW</u>	<u>Average Annual Energy GWH</u>	<u>Total Investment</u>	<u>Annual Cost</u>	<u>mills/kwr (including 1% Trans. Loss)</u>	<u>\$/KW</u>
Birch	165	560 (554*)	716,112	53,213	96	4,300
Goose	195	660 (654)	774,612	57,685	88	4,000

\*(554) reflects 1% transmission loss

#### Intergratability of Tidal Power

Tidal power output from a single pool system is dependent on the relative position of tides. Therefore, unless elaborate, expensive, pumped storage or other energy storing devices are built single pool tidal power project energy cannot be retimed. Single pool tidal power projects produce power intermittently following the lunar tidal cycle which lags the solar cycle by 50 minutes each day. This phenomena causes the tides and tidal generation to occur later each day. It occurs as often at 3 a.m. as it does at 6 p.m. Not only does tidal power advance daily, it varies in magnitude during each generating cycle from 0 at the start to full potential and back to 0 at the end of cycle. This is due to the fact that the level between the pool and ocean (head) varies throughout the generation cycle. Finally, the total available head for any generation cycle during a given month varies with the position of the moon and sun with respect to the earth. Figure 31 illustrates the relative forces exerted by the moon and sun and the resulting spring (large tide range) and neap (smaller tide range) tides.

Information on the timing and variability of tidal power generation has been developed by determining hourly generation for a typical one month period. The arbitrarily selected tidal month was that of July 1978.

The hourly generations were determined by first manually performing step routings for a spring and neap tide and establishing the timing and magnitude of the generation with respect to timing of high tide. Hourly generation for the month was then determined by extrapolation between the two routings, and the already available mean tide routing, with respect to timing from high tide and tide height as published in "Tide Tables" of the U.S. Department of Commerce. Figure 32 graphically shows the output from a hypothetical tidal power project. Table 24 shows percent of installed capacity available at a given hour.

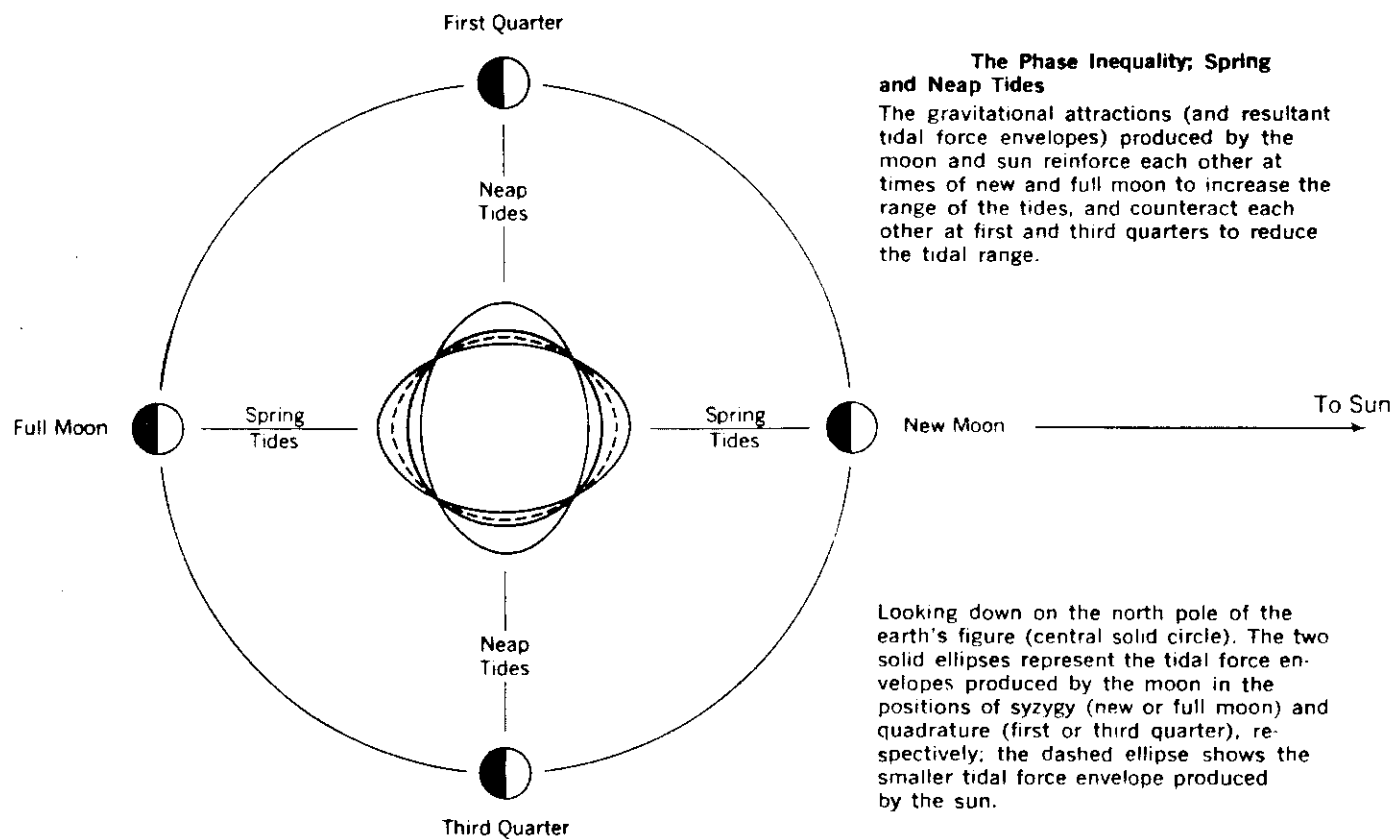


FIGURE 31

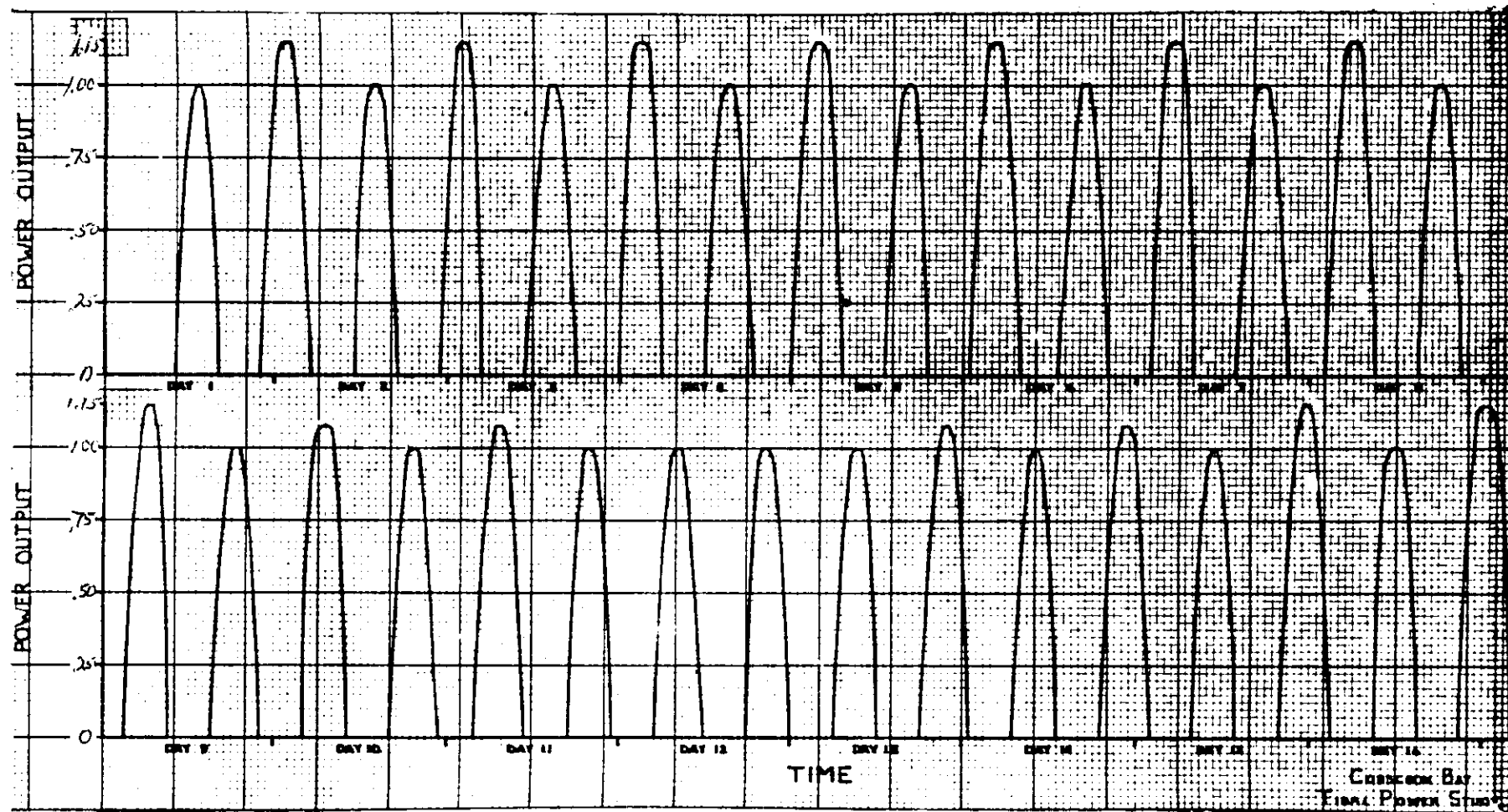


FIGURE 32

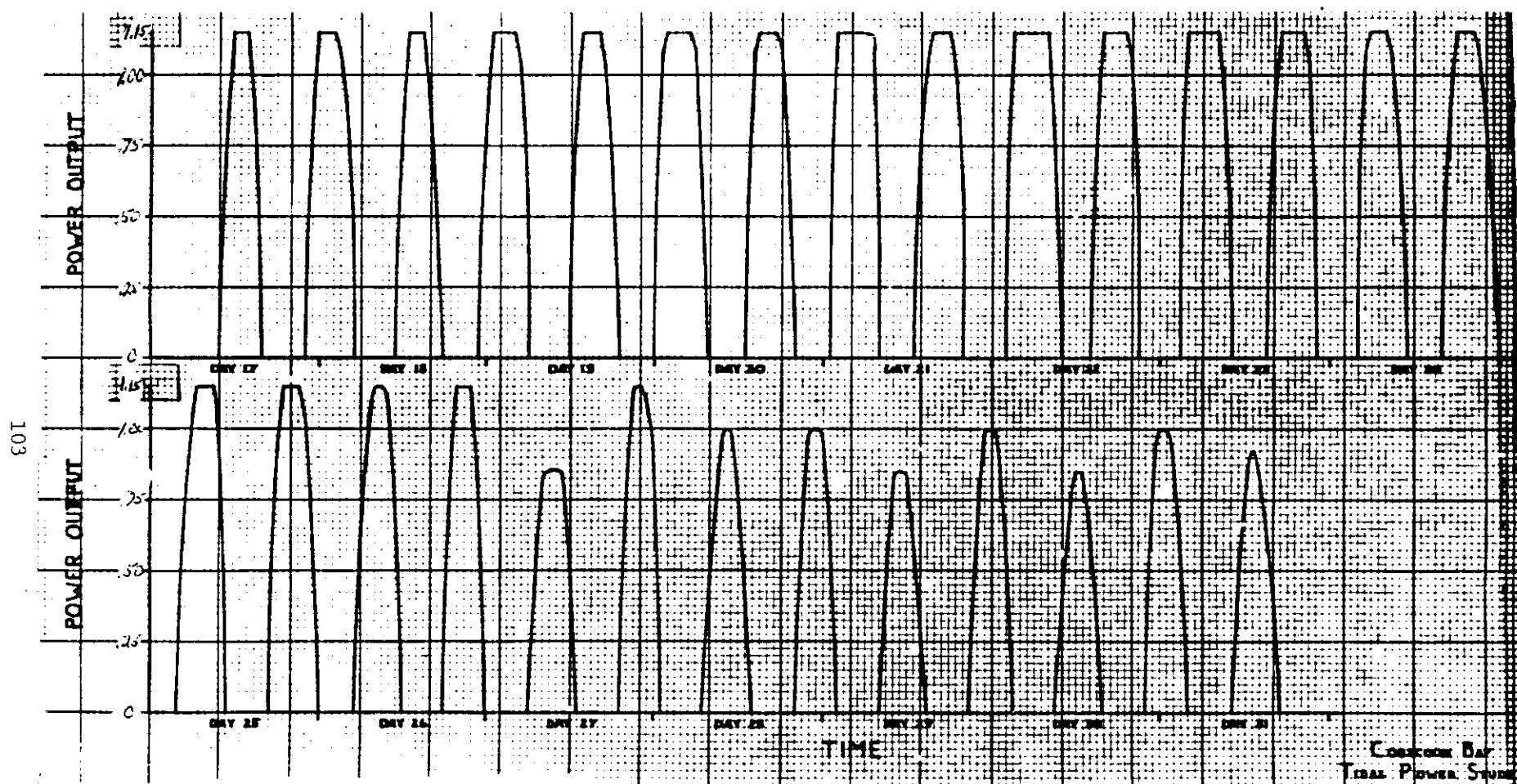


FIGURE 32



TABLE 24

TYPICAL TIDAL POWER OUTPUT  
- SINGLE POOL PROJECT -

Time Date	M	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
July 1	0	0	0	0	(0746-16.8)			0	0	0	0	.62	.92	1.00	.92	1.15	0	0	(2007-18.0)		0	0	0	.62	
2	1.08	1.15	1.15	.92	.38	0	(0838-16.8)				0	0	.85	1.00	1.00	.92	.46	0	(2007-18.1)			0	0	0	
3	.23	1.08	1.15	1.15	.85	0	0	(0923-16.9)			0	0	.38	.77	1.00	1.00	.85	.38	0	0	(2139-18.2)		0	0	
4	0	.85	1.15	1.15	1.15	.69	0	0	(1007-17.0)		0	0	0	.54	.92	1.00	1.00	.77	.31	0	0	(2221-18.3)		0	
5	0	.54	1.00	1.15	1.15	1.08	.54	0	0	(1048-17.1)		0	0	0	.69	.92	1.00	1.00	.62	0	0	(2301-18.3)			
6	0	0	.69	1.08	1.15	1.15	.92	.31	0	0	(1126-17.2)		0	0	.46	.77	1.00	1.00	.85	.46	0	(2339-18.3)			
7	0	0	0	.85	1.15	1.15	1.15	.77	0	0	(1204-17.3)		0	0	0	.62	.92	1.00	1.00	.77	.23	0	0	0	
8	(0017-18.2)		0	.62	1.00	1.15	1.15	1.00	.46	0	0	(1243-17.3)		0	0	0	.69	1.00	1.00	.92	.54	0	0	0	
9	(0057-18.0)			0	.69	1.08	1.15	1.15	.85	0	0	(1323-17.3)			0	0	.46	.85	1.00	1.00	.85	.46	0	0	
10	(0137-17.8)			0	0	.92	1.08	1.08	1.08	.69	0	0	(1403-17.3)			0	0	.62	.92	1.00	1.00	.77	.23	0	
11	0	(0219-17.5)			0	.54	.92	1.08	1.08	.92	.46	0	0	(1447-17.3)			0	0	.69	1.00	1.00	.92	.62	0	
12	0	(0306-17.2)			0	0	.54	.92	1.00	1.00	.69	.23	0	0	(1535-17.4)			0	0	.77	1.00	1.00	.92	.54	
13	0	0	(0357-17.0)			0	0	.62	.92	1.00	1.00	.62	0	0	0	(1626-17.5)			0	0	.46	.85	1.08	1.08	1.00
14	.54	0	0	(0451-16.9)			0	0	.62	.92	1.00	.92	.62	0	0	(1719-17.8)			0	0	.54	.92	1.08	1.08	
15	1.00	.46	0	0	(0550-17.0)			0	0	.69	.92	1.00	.92	.62	0	0	(1817-18.3)			0	0	.54	1.00	1.15	
16	1.15	1.00	.46	0	0	(0650-17.4)			0	0	.85	1.00	1.00	1.00	.62	0	0	(1914-19.0)			0	0	.77	1.08	

## Notes:

1. Output is expressed as a percent of installed capacity.
2. Output is determined assuming a 40% plant factor and a rated head of 10 feet.
3. Time and elevation (mlw) of peak tide is inserted appropriately during hours of zero power generation.

Cobscook Bay Tidal Power Study  
U.S. Army Engineer Division, New England  
January 1980

TABLE 24  
TYPICAL TIDAL POWER OUTPUT  
- SINGLE POOL PROJECT  
(Continued)

Time Date	M	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
July 17	1.15	1.15	1.08	.77	0	0	(0748-18.0)		0	0	0	.77	1.15	1.15	1.15	.77	0	0	(2012-19.8)		0	0	0	.85	
18	1.15	1.15	1.15	1.08	.85	0	0	(0844-18.8)		0	0	0	.92	1.15	1.15	1.15	.85	.46	0	0	(2108-20.7)		0	0	0
19	.92	1.15	1.15	1.15	1.15	1.00	0	0	(0939-19.6)		0	0	0	1.00	1.15	1.15	1.15	1.00	.54	0	0	(2201-21.4)		0	0
20	0	1.08	1.15	1.15	1.15	1.15	1.08	.31	0	(1033-20.2)		0	0	0	1.08	1.15	1.15	1.15	1.08	.62	0	0	(2255-21.8)		0
21	0	0	1.15	1.15	1.15	1.15	1.15	1.15	0	0	(1125-20.6)		0	0	.77	1.08	1.15	1.15	1.15	1.00	0	0	(2347-21.8)		
22	0	0	0	1.15	1.15	1.15	1.15	1.15	1.15	.31	0	(1217-20.7)		0	0	.85	1.15	1.15	1.15	1.15	1.00	0	0	0	
23	(0039-21.4)		0	0	1.15	1.15	1.15	1.15	1.15	.92	0	0	(1309-20.5)		0	0	.92	1.15	1.15	1.15	1.15	1.00	0	0	
24	0	(0131-20.7)		0	0	1.08	1.15	1.15	1.15	1.00	.62	0	0	(1401-20.0)		0	0	.92	1.15	1.15	1.15	1.08	.77	.38	
25	0	(0226-19.7)		0	0	.69	1.08	1.15	1.15	1.15	.92	0	0	(1455-19.3)		0	0	.92	1.15	1.15	1.15	1.00	.69		
26	0	0	(0320-18.6)		0	0	.62	1.00	1.15	1.15	1.08	.62	0	0	(1549-18.6)		0	0	0	.85	1.15	1.15	1.15	.85	
27	0	0	(0418-17.5)		0	0	0	.46	.85	.85	.85	.85	.38	0	0	(1646-17.9)		0	0	0	.77	1.15	1.15	1.08	
28	.92	0	0	(0518-16.7)		0	0	0	.46	.77	1.00	1.00	.77	.31	0	0	(1746-17.4)		0	0	0	.69	1.00	1.00	
29	1.00	.62	0	0	(0618-16.2)		0	0	0	.31	.85	.85	.85	.62	.23	0	0	(1842-17.2)		0	0	0	.69	1.00	
30	1.00	.92	.54	0	0	(0716-16.1)		0	0	0	.38	.69	.85	.85	.62	.15	0	0	(1937-17.3)		0	0	0	.77	
31	1.00	1.00	.92	.54	0	0	(0809-16.2)		0	0	0	.38	.77	.92	.85	.54	.15	0	0	(2028-17.5)		0	0	.38	

Notes:

1. Output is expressed as a percent of installed capacity.
2. Output is determined assuming a 40% plant factor and a rated head of 10 feet.
3. Time and elevation (mlw) of peak tide is inserted appropriately during hours of zero power generation.

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January 1980

The variability and timing peculiarities associated with energy output from single pool tidal power projects has always militated against such developments. During the course of this study, NEPOOL, New England's primary power planning and dispatching organization was consulted regarding the absorbability and integratability of 200 MW of intermittent power. NEPOOL indicated that it anticipated no problems in integrating the energy although studies would be necessary to determine specific electrical interties and operational impacts on the local system (reference xxx in correspondence appendix). If this study continues, system modeling will be undertaken to determine exactly what units tidal power would displace when operating. Based on Federal Energy Regulatory Commission findings the tidal power project will displace oil in the 1995 time frame (reference xx in correspondence appendix). Figure 33 below is a representation of what fuels might be used to meet New England's peak loads on 4 days in 1994 - 1995. Two hundred megawatts of tidal power has been superimposed to illustrate potential oil displacement. While it is impossible to determine exactly what units would not operate it is clear that oil fired units will likely be shutdown during tidal power production.

The question of integratability from an operational and electrical sense is a technical question. A companion economical question which is associated with integratability is what is the value of non-dependable capacity and intermittent predictable energy.

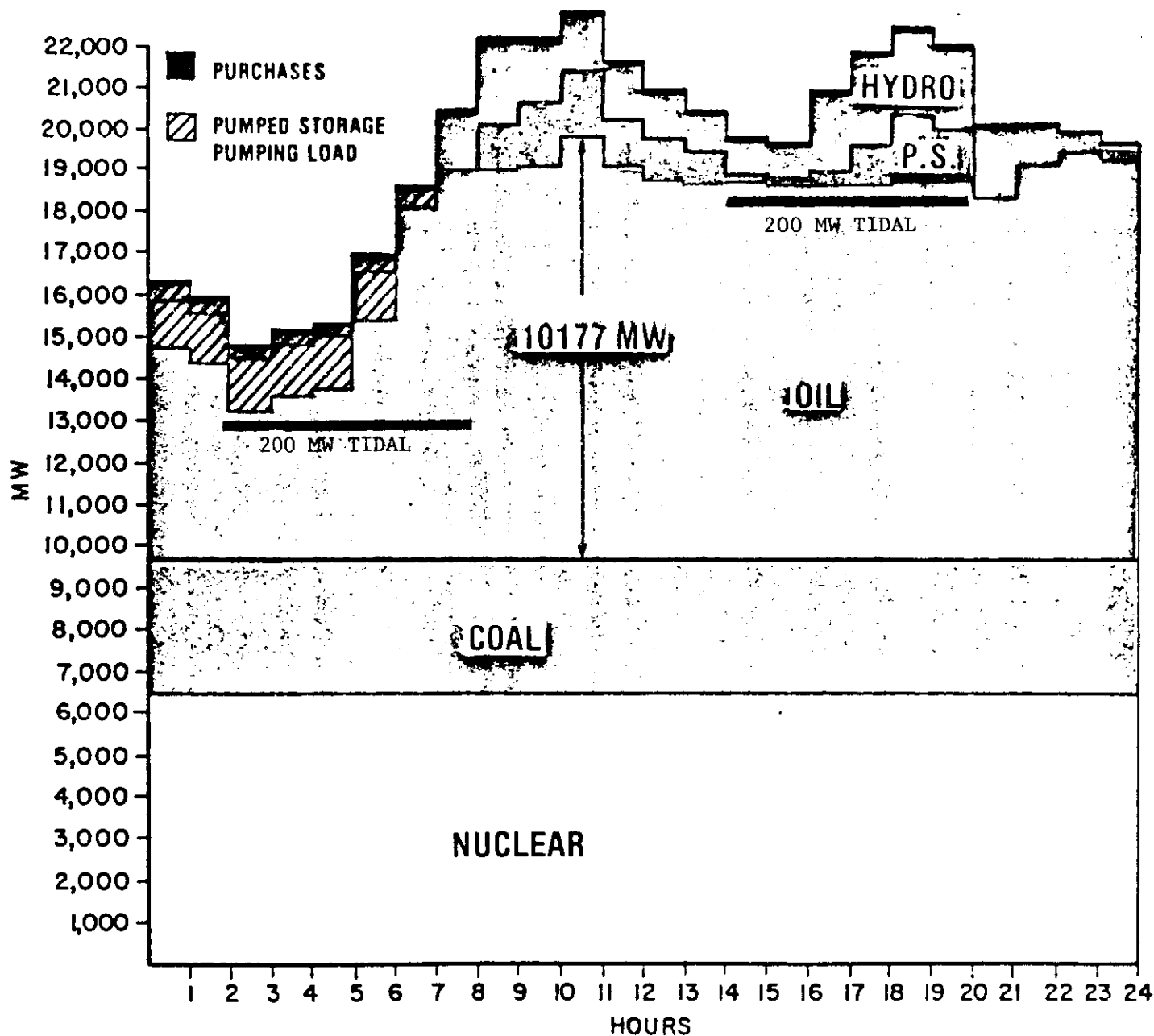
It is generally agreed that a single pool tidal power project has no dependable capacity. It can be demonstrated that like wind power the presence of a tidal power project in a system enhances system reliability and allows lowering reserve requirements without adversely affecting loss of load probability (reference 2). Therefore, it may be possible after detailed study to attribute some "capacity credit" to single pool tidal power projects. Currently, however, capacity is assumed to have no value.

The value of single pool tidal power project energy has been the subject of much analysis as it is the basis on which current Cobscook Bay Tidal Power Alternatives are judged for economic efficiency. This subject is discussed in the following section.

# NEW ENGLAND PEAK DAY DISPATCH - WINTER 1994/95

24 Units Converted to Coal & NEPOOL Planned Units

EXHIBIT 12



#### IV. ASSESSMENT AND EVALUATION OF PLANS

At this early stage of study detailed assessments and evaluations of plans are neither desirable or appropriate. Studies to determine the impacts of specific alternatives have not been undertaken. If the investigation continues such studies will be undertaken and specific impacts can be identified and addressed. In this report possible potential areas for impacts are identified and generalized comments regarding these impacts are presented. Economic evaluations of two plans are presented in detail since it is the result of these evaluations which play the largest role in the decision as to whether to continue this study.

##### Economic Evaluation

##### Economic Efficiency

The purpose of this section is to evaluate the National Economic Development Benefits (NED) which will accrue to certain tidal power alternatives.

The economic analysis contained in this section is unique in that it represents the first time that future real escalation in fuel costs has been factored into the estimate of benefits. This is based on directives contained in WATER RESOURCES COUNCIL; Procedures for Evaluation of National Economic Development (NED) Benefits and Cost in Water Resources Planning (Level C); Final Rule. (Federal Register, Vol. 44, No. 242, Dec. 14 1979, p. 72940.)

"In many cases, benefits may vary over the life of a project. This may be due to such factors as staged development of the hydropower project, changes in operation of the hydropower project resulting from changes in the resource mix in the total generating system, and real escalation in fuel costs if the most likely alternative is a thermal plant."

Other methodological changes contained in the WRC Procedural Manual which will be employed in the analysis are:

"(A) All interest and amortization costs changes to the alternative shall be calculated on the basis of the Federal discount rate; (B) no costs for taxes or insurance shall be charged to the alternative."

In recognizing the fuel escalation issue a report entitled "Preliminary Report on the Economic Analysis of the Project," Tidal Power Study Cobscook Bay Maine, was prepared by the New England Division in March 1979 and updated in July 1979 (ref. 33). The report evaluated hydropower benefits by the "static" conventional method, the "life-cycle" costing method and the "relative price shift (real fuel cost escalation

method)." Subsequently the method used was the subject of a Symposium held at the University of Maine at Portland, Maine (ref. 36).

The conceptual basis for evaluating the benefit from energy produced by hydropower plants is society's willingness to pay for these outputs. In the absence of direct measures of willingness to pay, such as marginal cost pricing, the benefit from energy produced by hydroelectric powerplants is measured by the resource cost of the most likely alternative to be implemented in the absence of the hydroelectric plant. The Federal Energy Regulatory Commission (FERC) formerly Federal Power Commission (FPC) has selected the alternative of an oil-fired combined cycle generating station to be most likely in the absence of hydroelectric facilities in Cobscook Bay as described in Section IV. The costs of the oil-fired alternative were estimated by FERC. The costs of the hydroelectric alternatives were estimated by the New England Division and include project first costs, operation and maintenance costs and transmission line costs.

When FERC estimates the costs of the thermal alternative, two costs are addressed, the capacity cost and the energy cost. The measure of the value of the hydropower project's generating capacity is the total of the thermal plant's amortized investment cost, transmission costs, interim replacement costs, and fixed operating and maintenance costs. The measure of the values of the hydropower project's energy production is the total of the thermal plant's variable operation and maintenance costs and fuel costs. Since there is no dependable generating capacity associated with these single pool tidal power projects, only the energy value is taken as an economic benefit. Using conventional power value calculation methods in January 1980 FERC indicated that for an oil-fired combined cycle alternative the corresponding hydroelectric energy value for the Tidal Power would be 49 mills/kwh.

The task of incorporating real fuel escalation into the computation of the energy value resulted in two separate sub-tasks to be addressed, namely (i) the appropriate framework of analysis and (ii) the approximate real fuel price escalation rates.

The framework of analysis chosen was relative price shift analysis. The method goes beyond a static benefit-to-cost comparison by considering changes in underlying price relationships that might occur over the life of the project. Real price changes, net of general inflation, are used. The use of relative price shifts is discussed in the Water Resources Council's "Establishment of Principles and Standards for Planning."

"When prices are used in evaluation they should reflect the real exchange values expected to prevail over the period of analysis. For this purpose, relative price relationships and the general level of prices prevailing during the planning study will be assumed to hold generally for the future, except where specific studies and considerations indicate otherwise."

The focus on real price relationships is important. The basic rationale for this approach is as follows: The monetary values of any good is ultimately valued in reference to other goods (goods refer to all things of value - i.e., labor, material goods) available in the market place. If all goods inflated at the same rate, then in effect their value would not be altered. By concentrating on relative price changes, we are considering fundamental changes in the valuation of a single good, which in this case is oil. Relative price shift analysis is used in order to fully quantify the benefit resulting from power generation with renewable resource. The price for any good can change relative to the general level of prices, therefore, in an era of continued inflation the need to focus price shifts among commodities gains in importance. The utilization of relative price shift methodology elicits the potential economic energy benefit associated with tidal power much more clearly.

Relative price shift analysis can be performed either by a series of hand calculations or through the utilization of a computer model. A model was created by FERC and is detailed in Chapter 5 of their August 1979 publication Hydroelectric Power Evaluation (ref. 40). Based on the capacity and energy costs of the most likely alternatives, the model is used to develop at-market power values for both tidal and other hydroelectric power.

For purposes of the Cobscook Bay Study, the relative price shift analysis was performed for the New England Division by the New York office of FERC. The power values were calculated by hand. No value for capacity has been taken for the project based on the following FERC rationale (ref. xxx Correspondence Appendix):

"...the electrical output of the two single pool projects is controlled by the tide and electrical power is available at approximately 13-hour intervals, for relative short periods, and at varying peak outputs. The availability of power from the project would occur with periods of peak utility demand only once every several days. For this reason, the capacity value (dollars per kilowatt-year) has been taken to be zero."

The energy value represents the total value of Cobscook Bay and reflects the displacement value of energy from oil-fired generating units from 1995 through 2095. Power values were calculated for the 38.6 percent capacity factor Goose Island configuration. The 100-year period of analysis begins with the expected project on-line date of 1995.

The cost of fuel oil displaced by the Cobscook Bay Project was escalated in accordance with the Department of Energy Office of Conservation and Solar Energy Tables which were published in the Federal Register on January 23, 1980 (ref. 7). The oil prices contained in the tables are escalated from 1980 through 2010, at a rate not including inflation (real

increases) based upon constant dollars. From 2010 to the 100th year of project life (2095), fuel prices were assumed to increase along with the general rate of inflation, i.e., no real increase using constant dollars. All displaced energy costs were discounted to the year 1995, using the Federal interest rate of 7-1/8%. These discounted costs were assumed and then multiplied by the 100-year capital recovery factor. The power values are shown below:

Cobscook Bay Power Values

<u>Capacity Value</u>	<u>Energy Values</u>
(\$KW-Yr.)	(Mills/KW Hr.)
0	108

A separate and concurrent relative price shift analysis was accomplished by the New England Division using a computer model (reference 33 and 40). Relative price shift energy values ranging from 105 to 115 mills/kwh were derived. This independent analysis used the same fuel price escalations (reference 7) as did the FERC analysis and appears to verify FERC's findings.

The relative price shift energy value supplied by FERC for the Goose Island alternative is 108 mills/kwh. The value of the 660 gigawatt hours of energy after a one percent reduction for transmission line losses is \$70,567,000 annually.

The employment benefit is based on the utilization of otherwise unemployed or underemployed local labor in the construction of the project. Based on the Direct Construction Cost of the Goose Island alternative, the amount allocated to labor has been estimated at \$150,343,200. The distribution among the labor force diversion is as follows:

TOTAL	\$150,343,200
Skilled	115,914,600
Unskilled	20,597,000
Other	13,831,600

The application of the appropriate percentage to ascertain the local labor bill based on Water Resources Council guidelines is found below.

Skilled:	\$115,914,600 x 30% =	\$34,774,400
Unskilled:	20,597,000 x 47% =	9,680,600
Other:	13,831,600 x 35% =	4,841,100
Total Local Labor Bill		<u>\$49,296,100</u>

Application of the 100-year capital recovery factor at an interest rate of 7-1/8 percent results in an annual employment benefit of \$3,515,800 over the first 100-year project life.



The measure of economic justification, the benefit/cost ratio, for the Goose Island alternative is above unity and is displayed in the summary below (Table 25).

Table 25  
SUMMARY OF ECONOMIC ANALYSIS  
Goose Island Alternative

Annual Benefits:	
Power	\$70,567,000
Employment	3,516,000
TOTAL	<u>74,083,000</u>
Annual Cost (7-1/8% 100-year)	\$57,865,000
Benefit/Cost Ratio	1.3 to 1

Similarly, the energy value supplied by FERC for the Birch Point alternative is 108 mills per kwh. The value of the 560 gigawatt hours of annual energy after one percent reduction for transmission line losses is \$59,875,000.

Based on the Direct Construction Cost of the Birch Point alternative, the amount allocated to labor has been estimated at \$138,320,000. The distribution among labor force divisions is as follows:

TOTAL	\$138,320,000
Skilled	106,644,700
Unskilled	18,949,800
Other	12,725,400

The application of the appropriate percentage to ascertain the local labor bill is found below.

Skilled	\$106,644,700 x 30% = \$31,993,400
Unskilled	18,949,800 x 47% = 8,906,400
Other	12,725,400 x 35% = 4,453,900
Total Local Labor Bill	<u>\$45,353,700</u>

Application of the 100-year capital recovery factor at an interest rate of 7-1/8 percent results in an annual employment benefit of 3,234,000 over the 100-year project life.

The benefit/cost ratio, which is a measure of economic justification, is above unity for the Birch Point alternative and is displayed in the summary below (Table 26).

Table 26  
SUMMARY OF ECONOMIC ANALYSIS  
Birch Point Alternative

Annual Benefits:	
Power	\$49,875,000
Employment	3,235,000
TOTAL	\$53,110,000
Annual Cost 7-1/8 % (100-years)	
	53,213,000
Benefit/Cost Ratio	
	1.2 to 1

In addition to the benefit/cost ratio, the internal rate of return (IRR) has, in some cases, been employed to assess economic feasibility. The internal rate of return is the discount rate at which annual costs and benefits are equal. The decision criterion is to reflect projects whose IRR is less than the expected cost of financing used to implement the project. At present, the interest rate applicable to Federal projects is 7-1/8 percent.

Table 27 below displays the fact that the percentage rate of return for each alternative is greater than the cost of financing.

Table 27  
COBSCOOK BAY - INTERNAL RATES OF RETURN

Alternative	Energy Value (Relative Price Shift)	Annual Benefits	Internal Rate of Return
Goose Island	108 mills/KWH	\$74,205,000	9-1/4%
Birch Point	108 mills/KWH	64,827,000	8-1/2%

For the purpose of determining the sensitivity of a tidal project's economic efficiency to the method of analysis used; i.e., conventional or relative price shift a conventional benefit to cost and internal rate of return analysis was performed. Using 49 mills/kwh (conventional energy value) instead of the adopted relative price shift energy value, the benefit to cost ratio for Goose Island (195 MW) was found to be 0.6 to 1. The internal rate of return using the conventional energy value is about 4%.

The interest rate at which the Federal Government can make money available to itself cannot, by law, increase by more than 1/4 percent per year. Historically it has been increasing at that rate. In anticipation of such an increase as of 1 October 1980, project costs have been refigured at 7-3/8 percent and Table 28 below presents a summary of both the 7-1/8 and 7-3/8 analysis.

Table 28  
ECONOMIC SUMMARY TABLE

Feature	Goose Island		Birch Point	
	7-1/8%	7-3/8%	7-1/8 %	7-3/8%
Installed Capacity	195 MW	195 MW	165 MW	165 MW
Dependable Capacity	0	0	0	0
Annual Energy	660 GWH	660 GWH	560 GWH	560 GWH
Energy Value	108	108	108	108
Energy Production Costs	88 Mills/KWH	92 Mills/KWH	96 Mills/KWH	100 Mills/KWH
Annual Cost (Total)	\$57,658,000	\$59,871,000	\$53,213,000	\$55,232,000
(Project)	54,370,000	56,479 000	49,898,000	51,840,000
(Trans.)	3,315,000	3,392,000	3,315,000	3,392,000
Annual Benefits (Total)	\$74,083,000	\$74,205,000	\$63,715,000	\$63,827,000
(Power)	70,567,000	70,567,000	60,480,000	60,480,000
(Emp.)	3,516,000	3,638,000	3,235,000	3,347,000
Benefit/Cost Ratio	1.28 to 1	1.24 to 1	1.20 to 1	1.16 to 1
Internal Rate of Return		9-1/4%		8-1/2%

#### Marketing

Another measure of a project's viability is its marketability. Basic power marketing guidelines are set forth in Section 5 of the Flood Control Act of 1944 (16 U.S.C. 1970 ed. sec. 825s) which provides that:

"Electric power and energy generated at reservoir projects under the control of the Department of the Army and in the opinion of the Secretary of the Army not required in the operation of such projects shall be delivered to the Secretary of the Interior (now the Secretary of Energy), who shall transmit and dispose of such power and energy in such manner as to encourage the most widespread use thereof the lowest possible rates to consumers consistent with sound business principles, the rate schedules to become effective upon confirmation and approval by the Federal Power Commission (now the Federal Energy Regulatory Commission). Rate schedules shall be drawn having regard to the recovery (upon the basis of the application of such rate schedules to the capacity of the electric facilities of the projects) of

the cost of producing and transmitting each electric energy, including the amortization of the capital investment allocated to power over a reasonable period of years. Preference in the sale of such power and energy shall be given to public bodies and cooperatives. The Secretary of the Interior is authorized, from funds to be appropriated by Congress, to construct or acquire by purchase or other agreement, only such transmission lines and relate facilities as may be necessary in order to make the wholesale quantities for sale on fair and reasonable terms and conditions to facilities owned by the Federal Government, public bodies, cooperatives, and privately-owned companies. All moneys received from such sales shall be deposited in the Treasury of the United States as miscellaneous receipts." (Dec. 22, 1944 CH 665 s5, 58 Stat. 890.)

Under the guidelines set forth in Section 5 of the Flood Control Act of 1944, the sale of power by energy should:

- Encourage widespread use of power
- Utilize lowest possible rates consistent with sound business principles.
- Make sure that rate schedules provide for cost recovery (financial feasibility).
- Provide preference in sale of power to public bodies and cooperatives.

The entire New England power industry is composed of almost 150 different organizations which are involved in electric generation, sales, or both. In 1971 a regional bulk power supply group was begun through the formation of the New England Power Pool (NEPOOL). The objectives of NEPOOL are: (a) to assure that the bulk power supply of New England conforms to proper standards of reliability and, (b) to attain maximum practicable economy, consistent with such standards of reliability, in such bulk power supply and to provide for equitable sharing of the resulting benefits and costs. This is accomplished through joint planning, central dispatching, coordinated construction, operation and maintenance of electric generation and transmission facilities.

Day-to-day scheduling and coordination of generating units and operation of transmission facilities are accomplished through NEPEX, a central dispatching agency provided for in the NEPOOL agreement. Pool participants subject all entitlements in generating units to NEPEX dispatch.

All transmission facilities rated 69 KV and above and which are owned by NEPOOL participants and which are required to allow energy from power

sources to move freely on the New England transmission network are considered to be pool transmission facilities (PTF). Each participant of NEPOOL is then entitled to use the PTF owned by other participants for a number of specified services including the transfer of entitlements of power purchases with both participants and nonparticipants.

The charges to NEPOOL participants for the utilization of these transmission facilities are under the determination of the owning company, unless the generating facility source is classified by NEPOOL as a "pool planned unit." Such designation dictates the availability of a New England wide "postage stamp" transmission rate for "wheeling" over the integrated 230 KV and 345 KV pool transmission facilities (EHVPTF) and further avail as another separately computed postage stamp rate for transmission service over any lower voltage pool transmission facilities (LVPTF) required for use in wheeling of the power to the purchaser.

Yearly charges for use of the EHVPTF (230 KV and 345 KV lines) for wheeling the output of a pool planned generating unit to the NEPOOL member amounted to \$3.00 per KW per year in 1979. Additional wheeling charges may be made by individual companies for wheeling power over non-PTF transmission facilities and/or subtransmission facilities.

Due to the many diverse entities involved in supplying power in the New England States, it is difficult to get exact figures on total electric loads. It appears, however, that the total peak load of the New England area in 1979 was approximately 15,300 MW. Of this, approximately 1,500 MW represented power demand in the State of Maine.

Municipal electric systems and cooperatives (preference customers) located in the New England States had combined load of some 1,450 MW. Of this amount, municipalities and cooperatives in Maine had loads of approximately 51 MW.

Given below are the peak demands of preference customers in 1979 followed by tabulation of generating capability:

#### PREFERENCE CUSTOMER PEAK DEMANDS

<u>State</u>	<u>Municipalities</u> MW	<u>Cooperatives</u> MW	<u>Total</u> MW
Maine	33	18	51
New Hampshire	30	98	118
Vermont	134	41	175
Massachusetts	881	-	881
Rhode Island	5	-	5
Connecticut	217	-	217
Total	1,290	157	1,447

# PREFERNECE CUSTOMER GENERATING CAPABILITY

<u>State</u>	<u>Generating Capacity</u> MW
Maine	3
Connecticut	58
New Hampshire	4
Vermont	69
Massachusetts	434
Rhode Island	-
Total	568

Given below are pertinent projections of preference customer loads and total loads for the State of Maine and the entire New England area. Projected loads for preference customers are based on an average load growth of 5 percent for cooperatives, 4 percent for Maine municipalities, and 3.2 percent for other New England municipalities. Total New England load are conincident peak loads based on NEPOOL loads as estimated by NEPOOL Planning Committee, as of April 1, 1980.

	<u>Maine</u>		<u>Total New England</u>	
	<u>Preference</u> <u>Customers</u>	<u>Total</u> <u>Loads</u>	<u>Preference</u> <u>Customers</u>	<u>Total</u> <u>Loads</u>
1979	51	1,563	1,447	15,311
1990	78	2,507	2,074	20,650
2000	124	3,710	2,923	28,707

Rates presently charged to prefernce customers vary substantially throughout the New England area with the lowest overall rates charged in New Hampshire and Maine and higher rates charged in Massachusetts, Connecticut, and Vermont. Existing rates on file at the Federal Power Commission as of January 1980 indicated that new higher rate schedules are now being applied to a great portion of the New England area. These filled rates contain capacity charges which vary from \$100 to 125 per KW per year in these latter three states. In New Hampshire and Maine, the present capacity charges are considerably below these levels. Energy charges all reflect fuel adjustment charges and are basically dependent upon the fuel costs which are incurred in each of the various areas. Because of the fuel adjustment charges, overall wholesale power costs for preference customers approached 40 mills per KWH in Maine during the latter part of 1979 (ref. 47).

For a project to be considered financially feasible, the Federal Government must be able to sell (market) power produced from project at a price which will allow the Government to repay itself within 50 years at an interest rate of 8%. The Corps of Engineers does not sell power which it generates. The Department of Engery (DOE) is responsible for marketing Corps generated power. In the northeast, their is no DOE marketing agency,

therefore, any power generated by the Government at Cobscook Bay would most likely be marketed by the Southeast Power Administration (SEPA) which is located in Georgia. Based on December 1979 - January 1980 price levels, SEPA estimated that power from the 195 MW Goose alternative would have to be sold at 94 mills/KWH to be financially feasible. Therefore, the Government would have to find a market willing to pay about 97 mills/kwh (includes about 2-3 mills/KWH to cover SEPA's administrative expenses). SEPA concluded that since the current 1980 value of similar oil fired energy is only about 50 mills/kwh that no such market exists (correspondence appendix). However, the Federal Energy Commission using relative price shift analysis calculated that similar oil-fired energy would cost 108 mills/kwh in 1995 (correspondence appendix).

If general inflation impacts oil price and construction costs equally and if DOE's real fuel price escalation projections (ref. 7) materialize, it appears as though the tidal power alternatives considered will be economically feasible and possibly marketable in 1995. The year 1995 is the mostly likely on-line date projected for the alternatives under consideration. It is expected that the detailed engineering and environmental studies required for such projects would require 8 to 10 more years and that actual construction would require 4 to 6 years.

#### Social, Economic, Cultural and Recreational Considerations

##### Socioeconomic

If a tidal power project were built in the Cobscook Bay area the occurrence of its social and economic impacts would be confined to certain geographical areas. Three impact areas have thus far been designated, the construction impact area, the service impact area, and the regional impact area.

Impacts can be described in the context of a construction impact area including the four communities of Eastport, Lubec, Perry and Pembroke. Impacts experienced within this impact area would be attributed to the actual construction activities, including impacts from any land takings or impacts from the use of local roads to gain access to the project sites. During construction, trucks and other construction apparatus will cause an increase in traffic and offer problems typically associated with a large influx of workers. The presence of large tidal dams will impact on navigation, in spite of the planned locks. Construction of a road across the dams of either the Birch Goose, or Dudley alternative would substantially shorten the driving distance between Lubec and Eastport. This would enhance economic development in both communities.

A service impact area has been designated which includes those communities that might be chosen by construction workers for temporary residence. Communities within this impact area will be described in terms of their municipal services, municipal finance, and housing, and their potential to service the construction workers. At this time it is felt

that Calais, Eastport, Lubec, Machias, Perry, and Pembroke make up the service impact area.

Washington County is considered to be the regional impact area. Regional impacts generally take the form of long term economic changes. In the case of a tidal power project, Washington County will probably see an increase in tourism and possibly a slight stabilizing effect on electric rates. At some future time if such stabilized energy costs do become a reality, industry might be attracted to Washington County. If the study is continued regional impacts will be addressed in detail.

During the 5 year construction period the most drastic impacts would be felt and they would occur primarily in the service impact area (SIA).

The influx of construction workers to these rural Maine communities is expected to be the major source of social and economic impacts of a tidal power project. The first task in delineating the social and economic impacts of the tidal project is determining the number of nonlocal construction workers.

Once the number of nonlocal construction workers has been estimated, how these workers would distribute themselves within the local communities should be determined. Scenarios would be related to the housing schemes as to which communities would absorb the bulk of the construction workers and how the housing supply and municipal services would be impacted.

For preliminary identification of impacts, a service impact area has been designated which includes Calais, Eastport, Lubec, and Machias. These four communities are among the largest communities in Washington County and would offer the construction worker the most in housing and service and are within approximately an hour's drive of the project site, with Eastport within about a half hour's drive. The majority of the county's communities are within about an hour and a half, but many communities are very small and are not felt to offer any amenities or opportunities that would attract the construction workers over the larger communities identified above. Of the smaller communities, it is possible that Perry and Pembroke could be selected to accommodate a mobile home "city" or some concentrated arrangement of construction workers. Construction worker surveys performed by the Institute of Water Resources (IWR) revealed that construction workers overwhelmingly locate in those communities located closest to the project site.

Investigations at a later date will consider numbers of workers that may choose to locate in the smaller communities that may be within a half hour drive of Eastport. These numbers could be substantial with a housing scenario reflecting the concentration of workers in a trailer/mobile home city rather than one reflecting a more liberal choice among housing options.



A 1977 study of twelve water resources projects for the Bureau of Reclamation outlined and analyzed the characteristics of construction workers. These projects were in rural areas in seven western states. More recently the Institute of Water Resources (IWR) has compiled data on construction work forces at projects constructed in the Northeast. Review of the results of both of these study efforts provides a base for projecting construction worker characteristics to estimate potential impacts of such an influx on the Cobscook Bay region.

A major distinction to be pointed out which accounts for significant divergencies in the Bureau of Reclamation and IWR data is the fact that projects surveyed by IWR were in the densely populated northeast whereas the Bureau of Reclamation studies were in rural western states. Although Cobscook Bay is in the northeast, the Bureau of Reclamation data may be more applicable, since this region in Maine is sparsely settled.

The Bureau of Reclamation studies indicated that on the average, 53 percent of the workers moved into the project area from elsewhere, establishing new residences. Approximately 25 percent of the nonlocal workers are single, and 75 percent are married. Those moving into the communities who are married have an average family size of 3.57 persons, with 65 percent of these workers bringing their families with them to the construction site.

Although housing choices of nonlocal workers were obtained through the questionnaires, workers were asked the type of unit at their local place of residence. The results showed that half of the nonlocal people moved into trailers, campers, or mobile homes while the other half chose single family homes or apartments. This differed from the housing units of local workers who indicated that 22 percent lived in mobile homes, trailers or campers, with 71 percent living in single family homes and 7 percent in apartments.

In the study being conducted by IWR the workforce was composed of 6 percent local workers and 31 percent nonlocal workers. Approximately 43 percent of the nonlocal work force occupies single family homes and apartments, 29 percent stayed in motels, 20 percent occupied mobile homes and trailers.

This study clearly indicated that closeness to project is the major consideration in choice of housing. This finding was also supported by the Chief Joseph Dam study which indicated that "construction workers preferred to live close to the project rather than in a community a short distance away which had more social and economic amenities."

Preliminary estimates indicate that the tidal power project in Cobscook Bay would have a construction period of five years. The work force would peak between April and October of the fourth year and 1900 workers. It is expected that construction would start with about 600 and end with about the same number five years later.

Inposing Bureau of Reclamation percentages on the peak work force for the Cobscook Bay tidal project of 1900, 1,007 construction workers would move into the area during peak. If 65 percent of the 75 percent nonlocal married workers brought families averaging 4 persons per family a total of 4,963 family persons plus the 251 single construction workers would produce a population increase of 2,214 during the construction period.

Housing is of particular concern, not only because of the limited number of housing options open, but also because concentrations of construction workers in particular communities would impact municipal services, including education facilities as well as water supply, sewage and solid waste disposal.

At a workshop held in 1978 (reference 31) interest was expressed for providing construction worker housing that could be turned over for local use at the end of construction. Housing does not now exist for the size of the work force needed to build a tidal project. Workshop participants felt that the housing which is developed should be of good quality to be useful in the future for tourism or other economic development schemes.

Two major scenarios for housing construction workers deserve consideration: either integrating workers with the local communities or segregating the work force probably in some type of trailer or mobile home "city" which could be removed after construction is completed. Two scenarios which should be addressed include the possibility of converting large, old homes to their original function as boarding houses, and the utilization of Quoddy Village, constructed when the Passamaquoddy Tidal project was started in 1935.

Several tasks would be accomplished during study progress to reveal the implication of a tidal power project would have on the housing situation. These include an inventory of the existing housing stock within a commuting range, examination of scenarios for distributing the work force, determination of local preferences for housing the in-coming workers in the interest of immediate and long range social and economic well-being, determination of the housing the indigenous area is willing to furnish such as motels, hotels, rooming house rentals, etc.

The provision of services, dependent on the distribution of construction workers, is a major concern. The particular issue raised at the workshop was who would be responsible for the services, such as sewage treatment, water, law enforcement, schools, etc.

The magnitude of the impact on local services would be closely tied to the distribution of the construction workers, the existing capacity of municipal services, and the current level of use of each service.

Future tasks in determining the impact of a tidal power facility on local service would first include a complete inventory of existing services, current level of use and existing capacity, with a highlight on those services in shortage.

Other studies have already been completed that deal with the service issue. These studies call for comprehensive planning and coordination among local, State and Federal agencies for obtaining grants and funds to relieve the pressure of construction activity in municipal services. In one particular instance (Chief Joseph Dam in Columbia, Washington) the Corps was responsible for obtaining funds to mitigate the project's impact on school facilities. With the addition of funds from the local communities permanent schooling facilities were provided that would accommodate those children brought with a construction work force and the local needs once the work force had left.

Once service needs of the construction work force and shortages caused by them are determined, management of these will be investigated.

Along with the service issues, a concern is the kinds of local government problems that a project would create. Specially what is a project's impact on law enforcement. If the study continues these and many other socioeconomic issues will need to be addressed.

#### Cultural

None of the four alternative project locations presently being considered have recorded prehistoric sites at their landward ends. However, as archaeological survey of the region is still incomplete, an archaeological reconnaissance of these areas will become necessary if project planning proceeds to further stages of study. As operation of the completed project would decrease tidal fluctuation, erosion of prehistoric coastal sites around the pool would be diminished.

Nearly all of the alternative dam locations under consideration tie-in to rural areas of coastline where historic resources appear unlikely to exist. The single exception is the Lubec end of the Dudley alternative, which occupies a commercial waterfront area. Historic structures or historic archaeological resources may exist in this area. If the Dudley alternative is pursued in further planning, the presence or absence of such resources will be determined and potential effects of construction activity considered in more detail.

The considerable tidal fluctuation and narrow channels of Cobscook Bay probably resulted in numerous wrecks, some of which may be of historic significance. While wrecks within the alternative pool areas would remain unaffected by project construction and operation, any within the dam construction limits would be destroyed. Further research will be undertaken at the next stage of project planning to determine whether any historically significant wrecks are located within the proposed dam construction areas.

## Recreational

It is probable that a public roadway will be planned to cross over the dam(s) at whichever alternative may ultimately be constructed. This will be particularly significant from a public recreation/ access point of view, especially for the Dudley, Goose and Birch alternatives. Lengthy driving distances to and from various locations around Cobscook Bay would be greatly reduced, thereby making existing recreational facilities more accessible with a better potential for increased visitation. The tidal power project in itself would be an important tourist attraction. If it were located along a major transportation route, which would be the case with three of the proposed alternatives and to a lesser degree with the Wilson alternative, then visitation to this project alone could be expected to be significant.

The only major recreational attractions in the vicinity of Cobscook Bay are Quoddy Head State Park, Cobscook Bay State Park, Moosehorn National Wildlife Refuge and the tourist/resort areas of St. Andrews, New Brunswick and Campobello Island. St. Andrews and Campobello Island, and to a lesser extent Cobscook Bay State Park, are destination recreation areas which offer overnight facilities.

Quoddy Head State Park offers about a dozen picnic sites, parking, rest rooms, drinking water and a short hiking trail. It is not near a heavily traveled main route and offers little in the way of a recreational attraction, thereby receiving relatively light visitation averaging around 60,000 people annually. The Moosehorn National Wildlife Refuge provides a visitor center for passing tourists, and even though U.S. Route 1 crosses the refuge, it still receives relatively light visitation averaging around 25,000 people per year. Cobscook Bay State Park has 150 camp sites, two short hiking trails, a boat launching ramp, rest rooms and drinking water. The park is located off U.S. Route 1, but is primarily a stopover for campers and tourists on their way to Canada and is not an attraction to the area itself. Visitation in recent years has averaged a little over 40,000 people annually, about half of whom are campers.

The principal towns in the immediate vicinity of Passamaquoddy and Cobscook Bays are Eastport and Lubec, Maine and St. Andrews, New Brunswick. Lubec and Eastport are both depressed areas surviving on a declining fishing economy, while St. Andrews is a much more attractive tourist area with several recreational facilities. In addition to the Roosevelt Memorial, Campobello Island also has several beaches and camping areas. Except for Calais, Maine and St. Stephen, New Brunswick, most of the rest of Washington and Charlotte Counties is rural, poor and depressed, and offers relatively little to tourists and recreationists.

Consequently, considering the nature of the Cobscook Bay area and the fact that most of the visitors to the region are tourists on their way to Canada, the proposed tidal power project cannot be expected to experience particularly high visitation. The project would be an attraction to

sightseers, especially if a highway over the dams were provided to improve access through the area, but would not offer much in the way of recreational facilities other than possibly a boat launching ramp, picnic area, and a visitor center.

Most of the recreational boating in the area is by local residents and is very limited due to the local economic climate and the rather dangerous tidal conditions, as well as the often poor weather and short summer season. A tidal power project would enhance recreational boating to a small degree by reducing tidal fluctuations, but the future potential for increased use would still remain low. Picnicking use is also expected to be relatively low since picnicking would mostly be incidental to sightseeing. Therefore, the only significant recreational activity which can be directly associated with any of the four power project alternatives is sightseeing. A project visitor center possibly in association with the power house facilities, would be the primary recreational development.

Visitation to existing recreational areas and attractions in eastern Maine and New Brunswick, including Cobscook Bay State Park, Quoddy Head State Park, Moosehorn National Wildlife Refuge, Acadia National Park, Franklin D. Roosevelt International Park and Fundy National Park, has been relatively steady in recent years with no significant trends up or down. This has also been generally true at Corps of Engineers flood control and navigation projects in New England where public recreational facility use has increased slightly at some projects while decreasing slightly at others, but with only a small upward trend overall.

Construction of a tidal power project at Cobscook Bay would probably result in increased visitation for the first few years after completion, but, assuming current trends continue, level off and stabilize after several years. Based upon experienced visitation at other Corps projects, Maine State Parks and other recreational facilities that offer a useful comparison, the projected visitation at the proposed Cobscook Bay Tidal Power Project at completion of construction is estimated at 200,000 people annually. It is reasonable to expect that visitation will gradually increase and level off at about 300,000 people annually.

These projections are based on current trends and experience with the assumption that energy costs, and gasoline in particular, continue to increase. It appears that the increased cost of energy will continue to adversely affect those recreation activities that depend upon gasoline for participation. These activities that require the use of an automobile to reach the place of participation will be the most severely affected. Consequently, this will undoubtedly limit visitation to the Cobscook Bay area, as present trends indicate that use of existing recreation facilities has leveled off since the energy "crises" began in 1973. With increased energy constraints recreationists are almost certain to participate in activities closer to home or take vacations at destination resort areas and limit the amount of driving.

## Environmental Considerations

Most of the ecological information available for Cobscook Bay is in the form of lists of species known or thought to occur in the area (reference 27). Little research has been done defining ecological relationships among the different organisms, abundance distribution, and life histories of species existing in Cobscook Bay. "The system is obviously very diverse and productive, yet little is known about the specific ecological processes that contribute to the diversity and exceptional productivity of Cobscook Bay," (reference 27).

Any environmental impacts which may occur depend upon the project's operational characteristics, such as pool size and mode of generating power.

Generally, a tidal power project would result in major impacts on the marine, estuarine, and riverine systems in the project area. Any alterations to these systems would affect circulation, salinity, sedimentation, temperature, shoreline erosion, flushing, ice formation, and nutrient levels. Nutrient and sediment supply would be reduced in intertidal areas and beaches, which, in turn, would result in significant alterations in the estuarine biota.

### Alternative Alignments

Wilson Alignment: The dam would extend from Leighton Neck, across Wilson's ledges and Red Island, to Birch Point. Leighton Neck and Birch Point consist of open fields, agricultural land, and rock ledges along the shoreline. Wilson's Ledges and Red Island are mainly rock ledges. Vegetation at the sites at Leighton Neck and Birch Point would be disturbed and removed due to construction activities. This impact would, in turn, affect wildlife in the area that depend on this for food and cover. Some species may return to the area after construction has been completed, with others having been displaced to different areas in their search for food. Some agricultural land may be taken out of use to build access roads and at the construction site. There would be adverse impacts on Wilson's Ledges and Red Island as most of the islands would be used to accommodate the dam structures. Rock would most likely have to be blasted and removed at the site. This would adversely affect any marine mammals, and migratory and resident shorebirds that utilize these areas.

Birch Point and Gove Point are the points of land where the dam abutments and powerhouses would have to be built. They both are made up of rock ledges and fields, with some forestland being present on Gove Point. Impacts on these areas would be moderate to severe as the facilities that are built would permanently alter the present state of the area.

Goose Alignment: The Goose alignment would extend from Goose Island to Mathews Island. Both islands consist of forestlands, open land, and rock ledges. Impacts on these areas would be similar to those associated with the previous alternatives.

Dudley Alignment: The Dudley alignment would include Estes Head, Treat Island, and Dudley Lubec, and Lubec Neck. The town of Lubec is located in the area to which the dam would extend. As this area has most probably been disturbed in recent years, impacts at this site would be moderate. Estes Head, Treat and Dudley Islands are made up of mostly field, forests and rock ledges which would be affected by construction of the dam facilities.

### Terrestrial Ecosystem

Impacts on the terrestrial habitat would be those mostly associated with transmission line construction and maintenance. These impacts will be dealt with on a generic basis at this time because the Department of Energy (Bonneville Power Administration) has not set forth final powerline routes. The general area studied by BPA is between Cobscook Bay and the Bangor area and is approximately 100 miles long and 50 miles wide.

According to a working paper on powerline right-of-way and wildlife management prepared by the Maine Department of Inland Fisheries and Wildlife in 1975, there are four areas which must be taken into account when determining transmission line routes. They are:.

1. Deer wintering areas
2. Wetlands
3. Streams, brooks, rivers and other bodies of water
4. Habitats supporting unique, threatened or endangered biota

Refer to USFWS Planning Aid Report, 1979 (reference 43), for a complete discussion of the management and associated impacts on these areas due to transmission line routing.

In addition to the impacts on wetlands caused by transmission lines, the construction of the tidal power facilities will also impact wetlands. Table 29 indicates the acreages of those wetland habitats which would be affected by the proposed dam alignments.

The Dudley-Treat-Lubec alignment would affect the most acreage of wetlands (8,957 acres), with the Wilson alignment affecting the least amount (1,373 acres).

TABLE 29

INTERTIDAL HABITAT AFFECTED BY  
PROPOSED TIDAL POWER DAMS

<u>Dam Alignment</u>	<u>Intertidal Habitat<sup>1</sup> (acres)</u>					<u>Total</u>
	<u>Mudflat</u>	<u>Rocky Shore</u>	<u>Aquatic Bed</u>	<u>Marsh</u>	<u>Beach or Bar</u>	
Wilson	829	150	218	87	89	1,373
Birch	4,144	1,278	961	553	153	7,089
Goose	4,719	1,472	1,249	592	210	8,242
Dudley-Treat- Lubec	4,990	1,610	1,382	605	370	8,957

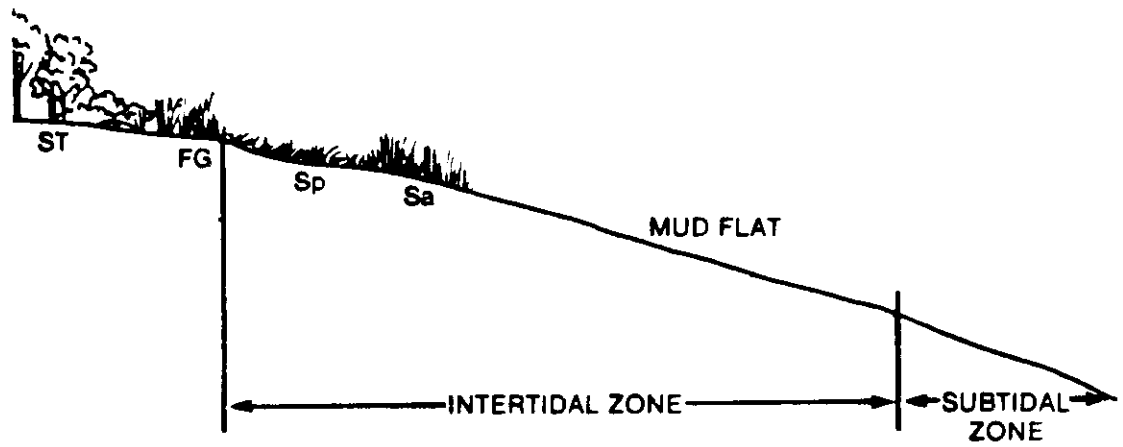
<sup>1</sup>Source of data: FWS National Wetland Inventory Draft Maps

As a result of the new tidal regime that would result in Cobscook Bay should a tidal power project be constructed, there would occur a migration of salt marshes towards the sea in the areas surrounding the bay. Spartina alterniflora and Spartina patens would be the major species affected. These species would shift down the tidal flats, resulting in an increase in salt marsh at the seaward edge, (see Figure 34). Wetland habitat would be increased in certain areas, providing available resources for waterfowl and aquatic mammals that utilize it. However, some salt marsh habitat would be lost as that vegetation associated with freshwater would also be migrating to the sea, taking over the salt marshes. Along with this, drainage of surrounding marshlands would be delayed because of the increased mean tide level. In effect, there would be a change in the distribution and type of vegetation, with a net loss of marshland probably occurring. This would in turn affect wildlife, waterfowl, birds, and marine organisms. Much of the intertidal habitat would be altered, and productivity impaired, with approximately half of the plant communities losing their productivity.

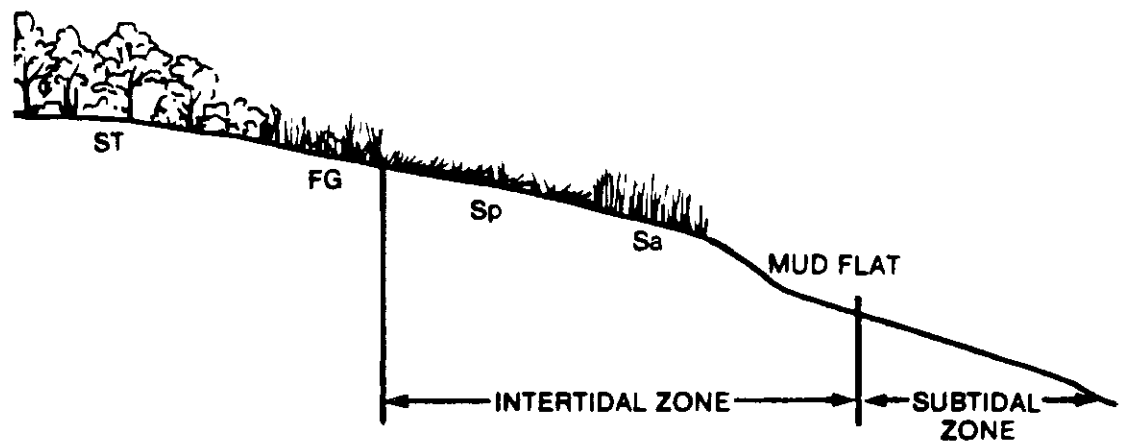
Agricultural land that is present in the bay area may be affected. Marshes have been dyked and used for agricultural purposes in the past. Because of an increase in the mean tide level, the drainage on this land will be reduced; thereby negatively affecting its current use. Impacts would include increased disease factors and nitrogen deficiency. Water levels will have to be controlled in drainage ditches in relation to what is being grown on the land, (reference 49).

Impacts on terrestrial bird and wildlife populations would depend upon their relationships and associations with the marine habitat upon which they depend for food. Should the particular habitat that they depend upon be negatively impacted by construction, this would in turn have negative





**EXISTING INTERTIDAL ZONE**



**POSSIBLE INTERTIDAL ZONE WITH IMPOUNDMENT FOR TIDAL POWER**

FG - FRESHWATER GRASSLAND  
 ST - SHRUBS AND TREES  
 Sp - SPARTINA PATENS  
 Sa - SPARTINA ALTERNIFLORA

➤ Conceptual effect of a new tidal regime on a generalized intertidal zone (Hodd 1977).

impacts on their survival. Populations would be displaced to other areas in search of food and shelter. These factors would put pressure on the existing populations which are assumed to be operating at maximum carrying capacity. The increases in pressure could eventually reduce productivity.

Noise from construction activities would result in short term impacts, with most biota returning to the area after completion of the project.

A survey of deer yards located in the areas of access roads and construction activities would be necessary.

#### Aquatic Ecosystem

All fish species found in the bay area are important biologically in the overall trophic ecology of the region. A major concern would be the effects of tidal power on the feeding and reproduction of the various species. Some depend on the intertidal benthic organisms as their main food source. The food source would be adversely affected as a result of the reduction of the intertidal zone due to project implementation.

Most species could decrease in abundance if their movement is impeded by the project. Winter flounder (Pseudopleuronectes americanus) is the only known species which has a substantial spawning population within Cobscook Bay (reference 16).

A critical impact would be associated with the diadromous fisheries of the bay. Their spawning migrations will be impeded by construction activities unless fish passage facilities are provided. Important species that would be affected are alewife, smelt, and Atlantic salmon. In addition to impediment of movement upstream to the rivers for spawning, there are also impacts associated with the movement of juveniles and adults moving downstream through the powerhouse. There has been little information gathered in relation to the effects of turbines on finfish. This could result in a high mortality rate caused by blockage because of negative currents, flow in a dark tunnel, and no olfactory clues (reference 49). The extent of the mortality will depend on the extent of passage through the turbines.

In addition to the physical barriers presented by construction, the physical and biological aspects of the various habitats these species utilize for spawning and rearing will be affected, i.e., salt marshes, estuaries and nearby rivers. Also, any changes in the intertidal and subtidal habitats could negatively effect the food resources of any groundfish species which are heavily dependent on this particular habitat. Additionally, as some groundfish tend to be less mobile than the more migratory species, they are more likely to be caught up in the powerhouse facilities. At present there are no fisheries for winter flounder due to restrictions on otter trawling.

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Project construction would also cause some changes in circulation patterns and decreases in the current velocity behind the dam structures, which would result in deposition of sediments at the mouths of rivers and streams, and in the overall distribution of surface sediment types. Project construction and implementation could cause delays in the migrations of diadromous species. Those species that swim close to the surface possibly would be delayed only for the amount of time that the filling gates would be open. However, those fish which would go through at lower depths would be impeded unless passage facilities were provided.

Each of the dam alignments, Wilson, Birch, Goose, and Dudley, would adversely affect the movement of migratory species to freshwater for spawning. The fish are able to enter the Bay only through the passage between West Quoddy Head and Campobello Island. Fish passage facilities will have to be provided, with possibly different types being built to accommodate the various species.

While movement up the Pennamaquan River would be equally affected by each of the alternatives, the Wilson alignment would not affect migration up the Denny's River as passage would not be impeded through the channels leading to the river.

According to the report by Iles, 1975, in the proceedings of the workshop on Fundy Tidal Power and the Environment (reference 49), the complex ecological structures of zooplankton in the bay are related to specific hydrographic features, and that some biological elements found in the system provide food for or are predators on herring populations. As stated, "...any significant change in hydrographic regimes could be followed by a response in the biological system, which could be positive or negative, and could result in differing responses from different species."

As statistics on distribution, mortality, and size of stocks of the fisheries are inconsistent, it is difficult to specifically assess the impacts on these resources.

Herring will probably enter the bay through the filling gates. Because of this limited access, there is expected to be a reduction in the herring population. Some will pass through the turbines, but the extent of the mortality is not known. Mortality of juvenile and adult herring may also occur from increased water temperatures within the impoundment.

Pollock, haddock, cod, and redfish would be reduced greatly or possibly eliminated from behind the impoundment.

Site-specific analyses of impacts of tidal power on the commercial fisheries of the region are difficult to accomplish at this time. Basically, it can be said that there will be changes in fish populations in general. Additional information and analysis is needed on the distribution, abundance, and life history of those species that are found in the bay throughout the year.

Growth and maturation may be affected by changes in temperature and salinity, and the placement of a dam anywhere in the bay may affect migratory routes and change the overall distribution and abundance of food.

In summary, there would most likely be no net change in commercial herring populations, and a slight increase in the smelt fishery. Alewife and Atlantic salmon fisheries would decline appreciably unless fish passage facilities were provided to allow them to reach their spawning areas.

Much of the knowledge of intertidal populations of benthic organisms in Cobscook Bay is limited because of the lack of an extensive population sampling program. Impacts on benthos due to construction activities would occur from dredging and filling operations. The extent of impacts would depend on the abundance and distribution of the resources in the area of the dredge and filling activities. There could also be a reduction of benthic resources in the surrounding areas of the particular dredge and fill sites, with bottom habitat also being lost at the permanent dam sites. Indirect impacts on the benthic organisms would result from local current patterns being affected, changes in sedimentation, scouring, and nutrient transport (reference 27).

Primary productivity would be adversely affected by the construction activities because of an increase in turbidity, thereby reducing the amount of sunlight that would be able to penetrate the water column.

Impacts on benthos associated with the operation of the dam and related structures would be an increase in sedimentation due to reduction in tidal energy and a loss of mixing within the water column. Many organisms may not be able to survive substantial depositions of sediments. An increase in ice formation is also a possibility. This would cover the mud flats and benthos, which may not be able to survive this change. Most ice forms along the upper reaches of the intertidal zone. The production of the intertidal zone would be affected as a result of ice melting and scouring. A large amount of intertidal habitat would be lost should any part of Cobscook Bay be impounded. This is the result of habitat, normally exposed at low tide, now being covered with water through all tidal cycles.

Distribution of benthic invertebrates would be affected by the reduction of the intertidal zone. Changes such as redistribution and abundance in existing species composition could occur should sedimentation result in different particle sizes being present.

Some of the changes in the sediment type would be an increase in loose muddy substrates where populations of deposit feeding marine worm populations would increase. Impacts on the resident and migratory fish and bird populations would occur also as a result in these changes in the benthic populations. Because a new mean tide level would be established, there would be a shift in the height and width of the intertidal clam flats (reference 49).

Some organisms can survive sediment deposition by burrowing upward. However, such species as Mya cannot as adults (Risk, et al, 1977).

It has been estimated that soft-shell clam production would most probably decrease by about half, with the new clam zone that is created not being productive for about 10 years, but returning to the production capacity that was present before an impoundment was created (reference 27).

The permanent flooding of large areas of mudflats would therefore result in a large mortality for those species which are adapted to this environment. There may be a reduction in larvae production due to changes in current patterns and distribution of sediments.

The physiological processes of growth and reproduction could be affected by changes occurring in food supply and water temperature.

The Maine State Planning office has identified areas considered to be critical for certain invertebrates. These areas are Birch Islands, Crow Neck, and Wilburs Neck. They are populated with unique populations of invertebrates that consist of arctic species which are rarely found on the coast, or subtidal animals that are rarely found in the intertidal zone. Except for the Wilson alternative, all of the alignments being considered would impact these critical areas.

The effects of a dam in the bay on intertidal benthic animals would result in impacts on other resources present. They provide an essential food resource for fish, waterfowl, and shorebirds. The reduction of the zone would decrease the resources in proportion to the amount of area that would be exposed. The effects would vary, at some locations there would be a major impact on migratory shorebirds, and in some areas there would still be subtidal populations available for groundfish (reference 49).

In addition to the previously mentioned impacts, the effects on commercially important shellfish species within the impoundment would also vary. There may be a slight improvement in the lobster industry, depending upon the productivity of the resource at the time the project is constructed. The quality of the soft-shell clam may improve, but along with this would be a decline in the actual numbers because of the reduced intertidal zone. The impact would be greater in a high pool configuration than a low pool configuration. The blue mussel and sea scallop production would increase slightly, with production of the periwinkle declining. There would probably be no change in sea urchin production.

Warmer water temperatures that would be evident would stimulate the growth of some intertidal plants, which would possibly increase the feeding of littorina snails and urchins in intertidal and subtidal areas.

Many benthic populations would not be able to survive the new tidal regime, with organisms being displaced to habitats at new levels.

Phytoplankton production would be affected as a result of impacts on water circulation and temperature, nutrient distribution, and light penetration. Along with this, net primary production would be changed. (reference 43). The extent of this impact on individual populations can not be evaluated at this time. An analysis for each alignment would have to be performed to determine the extent of impacts on these populations.

Zooplankton populations within the bay would be affected by resultant impacts on the phytoplankton and distribution of detritus. Basically, any changes in abundance and distribution of zooplankton would impact other portions of the ecological structure in the bay. The study done by Legare and Maclellan in 1960 proposed that should a tidal power project be built, the impacts on zooplankton would not be significant as copepods in the overall area are tolerant of a wide range of temperature and salinity. However, those organisms that are more sensitive to physical and chemical changes, in addition to those in early stages of development, would be affected to the greatest extent.

Zooplankton would be affected by an increase in suspended particulate matter due to construction activities. Many of the organisms are filter feeders, and this turbidity could interfere with their feeding processes.

Phytoplankton would be least restricted in its passage into and out of the bay due to the operation of gates and locks at the dam.

A change in the flushing pattern could result in a reduction of plankton that are carried into the bay. As a result of an increase in the mean water level after the project is constructed, additional habitat for plankton may be created, thereby allowing a probable increase in primary production.

Impacts on marine mammals due to construction activities would most likely be minor in nature. However, when facilities are operating, the larger marine mammals would be very much restricted in their movement into and out of the bay. When the filling gates are closed, mammals already in the bay would be trapped, while those outside would not be able to travel through. The harbor seal has breeding populations in the area, and there could be a significant impact on them in the form of being trapped in the bay. The feeding habits, and also reproduction would be affected. Seal haulout areas are located within Straight Bay. The Birch, Goose, and Dudley alignments would prevent them from getting to these areas.

Harbor porpoises found in the bay may not be migratory and would depend upon the area throughout the year for food and shelter. These species would have to be studied fully to determine the extent of impact by the project.

Impacts on whales that are known to occur in the area would be similar to those for the seals and porpoises. The feeding habits of the whales differ among the various species, and this will have to be taken into account in the determination of dam placements.

With each of the dam alignments, marine mammals will be impeded in their movement into the bay. In particular, seals would be prevented from migrating in the spring up into the estuaries to their haulout areas, and again in late fall down the estuaries.

A large reduction in tidal flushing could result in the increased growth of blue-green algae. However with the additional reduction in exposed tidal flats at low tide, primary production from green, red, and brown algae would be reduced, (reference 49).

The seaweeds Ascophyllum and Fucus may increase in the rocky areas as a result of decreased wave exposure along the edges of the impoundment. However, as a result of increased sedimentation, the rocky substrate for macroalgae would most likely decrease, while the substrate for marsh grasses would increase.

Other factors that could affect the production of macroalgae would include ice scouring, wave action and grazing. These increase the rate of turnover of the algae thereby increasing the net growth. (Reference 27.)

Turbidity would limit the light available for subtidal plants which would influence the growth of kelp. In areas at or near the project site, growth would be limited to the shallower depths.

Any increases in the temperature regime of the bay would also affect the growth of kelp, as these species grow the fastest in low temperatures.

Productivity of macroalgae in the bay is influenced by the availability of light and suitable substrate, suitable salinities, water temperatures, and adequate nutrients. Any changes in these factors due to construction and operation would impact the growth of algae.

#### Avifauna

Construction of tidal power facilities would adversely impact those birds that feed on intertidal mudflats and in the vicinity of deepwater tidal rips (reference 42). The degree of impact would depend upon the operational mode of the particular facility that was built.

Those shorebird species most likely to be adversely affected by loss of habitat and food availability are semipalmated sandpipers, semipalmated plovers, and black-bellied plovers. Others include bonaparte's gulls, herring and black-backed gulls, and great blue herons.

Any changes in the draining of the bays would affect the tidal rips that are present. These rips concentrate the food upon which many birds depend. The area off of Eastport where tides converge from Cobscook and Passamaquoddy Bays provides a major feeding area for northern phalaropes bonaparte's gulls, herring and black-backed gulls, kittiwakes, and

dovekies These species would be affected by any changes in the oceanographic features of this particular area.

The availability and quality of marine invertebrate foods for waterfowl could be adversely affected due to changes in the water regime. Ice formation would also be a factor, however, but to what extent is not known.

Terrestrial species would be mostly affected by transmission line facilities. Mitigation measures should be taken to route lines away from migration routes, and away from routes between breeding and feeding areas.

#### Rare and Endangered Species

The bald eagle would be affected by a tidal power project in Cobscook Bay. However, because of the lack of substantive data, an evaluation of the magnitude of impacts cannot be done at this time. Should studies continue, food requirements, effects of development, and mitigation measures would have to be assessed. A detailed biological assessment would have to be completed.

The Maine Department of Inland Fisheries and Wildlife has proposed a bald eagle management program in order to restore a self-sustaining bald eagle population to suitable habitat throughout Maine.

Eagles have been sited at Denbow Neck, Trescott Island, Wilbur Neck, Edmunds, Clement Point, Coggins Head, Mt. Dorcas, Burnt Cove, and Hog Island. All of the dam alignments have the potential to affect the bald eagle's food supplies, which may affect its success rate of nesting.

The impacts discussed on marine mammals in the Cobscook Bay area which are on the Endangered Species List of the Endangered Species Act of 1973 would require consultation under Section 7 of the Act. The listed species include the fin, humpback, right sei, blue and sperm whales.

The shortnose sturgeon, which is also on the Federal list of Endangered Species, is anadromous in some tributaries in the Gulf of Maine. However, as it prefers large rivers, it is not probable that it would occur in the small tributaries found in the Cobscook Bay region, though it has been thought to be an occasional migrant into the Quoddy region. Further analysis would have to be carried out in order to determine the presence of it in the project area.

#### Water Quality and Hydrualic Conditions

Several alternate embankment locations have been proposed for the Cobscook Bay Tidal Power Project. Four single pool plans, (Dudley, Goose, Birch, and Wilson) have been advanced. All of these plans, except Wilson, would employ the inner bay as part of the high pool. Wilson would utilize only East Bay and the Pennamaquan River Estuary as the high pool. Behind



any of these embankments, current hydraulic conditions would be significantly altered.

Generally speaking, a single pool tidal power project operates by opening filling gates during the rising tide. In this manner the operating pool is filled to near the high tide level. The filling gates are then closed, and the turbines begin generation during the falling tide when a differential head exists at the embankment. The cycle is then repeated. Exact basin elevations for this project would depend on the results of refined hydropower studies.

The mean tide range in the operating pool of each alternative plan will be between 4.7 feet and 10 feet depending on the alternative selected. Regardless of which operating curve is adopted, water surface levels and rates of filling and drawdown will be significantly changed, however, the mean maximum tidal level will be within about one foot of the current level.

Filling of the operating pool will be through a series of 30 foot by 30 foot filling gates. Maximum velocities through these gates are estimated to be near 20 feet per second. Bulb type turbines will be provided to generate electricity, and exit velocities will be in the range of 18 feet per second. Table 30 provides information on inflows and outflows for the alternative considered.

Currents within and immediately outside of the power pool will be significantly affected in magnitude and direction. The volume of water passing the embankment site will be considerably less than at present and will be concentrated through the turbine and filling gate openings. Reduced currents in the operating pool will have a tendency to decrease the degree of mixing which currently takes place. Residual currents outside the pool would be minimally affected.

TABLE 30

PERTINENT DATA  
ALTERNATE EMBANKMENT SITES  
COBSCOOK BAY TIDAL POWER PROJECT

Embankment Alignment	Surface Area (High+Mean)/2 (acres)	Maximum Filling Rate		Maximum Generating Rate	
		Largest Installed Capacity Factor (10 <sup>5</sup> cfs)	Smallest Installed Capacity Factor (10 <sup>5</sup> cfs)	Largest Installed Capacity Factor (10 <sup>5</sup> cfs)	Smallest Installed Capacity Factor (10 <sup>5</sup> cfs)
Dudley	23,123	9.2	5.1	14.	1.7
Goose	19,379	7.7	4.3	12.	1.4
Birch	16,582	6.4	3.7	10.	1.2
Wilson	3,552	1.4	0.79	2.2	0.26

The unusually large tide range in the greater Bay of Fundy area has been attributed in part to the relationship between physical dimensions and the frequency of tidal oscillation. Construction of a tidal power project at Cobscook Bay would likely have some impact on raising tide levels of the surrounding water. Only through further study could this effect be quantified, however, at this time it is felt that the effect will be minimal.

Reduced currents within the operating pool area will result in decreased vertical mixing which in turn will give rise to increased thermal stratification and greater seasonal variations in water temperature. The greatest temperature change would likely occur at the surface layer with a smaller change observed at the deep layer. There is a strong possibility that some amount of ice cover would develop on the pool during the winter months. Little temperature change would be expected outside of the pool area.

The mean surface salinity of the operating pool would likely be reduced. Bottom salinities would likely be altered only slightly. Since there is relatively little freshwater inflow to Cobscook Bay it is not likely that significant stratification of fresh and saline waters would develop. If any of this type of stratification does develop, Dennys Bay is the most probable location since this has the largest freshwater inflow. Outside of the operating pool little change is expected except for the emptying and filling areas where some decreased salinity would occur.

The vigorous tidal mixing currently taking place in Cobscook Bay promotes dissolved oxygen levels near the super-saturation level. Under the proposed plans mixing in the operating pool will be decreased, and it is likely that dissolved oxygen levels in the deep basins of Cobscook Bay will be reduced.

Suspended sediment concentrations in the water column will increase during construction of the project. The main sources of this increased loading will be the suspension of materials being used to construct the embankment and the resuspension of bottom sediment in the vicinity of construction. This temporary increase in suspended sediment will likely promote a short term degradation of other measures of water quality.

Some permanent change in type and distribution of sediment could be expected. Reduced range of water levels and wind fetch should cause a decrease in shoreline erosion within the operating pool. Lower energy levels in the pool should cause more sediments to deposit, thus impacting the distribution of marine sediments. Some deposition of sediment at the mouths of freshwater inflows could be expected.

Construction of the proposed Cobscook Bay Tidal Power Project will significantly alter the hydrodynamic conditions currently existing in the bay. The tide range behind the barrier will be greatly reduced, the mean

pool level will be raised, currents and velocities within the pool will be reduced, and less mixing will take place. The potential exists for some stratification of salinity, temperature, and dissolved oxygen, and some winter icing could occur. Levels of suspended sediment and associated degradation of overall water quality will occur during construction and long-range, sediment circulation and deposition patterns will be changed.

Fairly high velocity flow will occur through the filling gates and turbine outlets. This will impact the area outside and adjacent to the embankment structure. Little overall effect is expected on the open ocean away from the structure, however some small increase in tide level is likely due to the closing off of Cobscook Bay.

All data and conclusions presented in this section has either been extracted from or based upon existing literature. No water quality oriented studies were conducted for this report. Therefore, only statements of a general nature could be made regarding effects of the proposed tidal power project. More quantitative predictions can only be made through more detailed study.

The physical characteristics of Cobscook Bay must be well documented, and accurate bathymetric data must be developed. This information will prove essential in the development of physical and mathematical models.

Sufficient tide gages should be established within Cobscook Bay to confirm the results of previous studies and to develop a full understanding of how the bay responds to the changing tide. The direction and magnitude of tidal currents should be documented for all parts of the bay during at least four times throughout the tide cycle, including spring and neap tides. Currents at surface and lower levels should be measured in order to describe the movement of the entire water column.

Profiles of dissolved oxygen, salinity, pH and temperature should be developed throughout Cobscook Bay. A sufficient number of profiles should be measured in order to typify conditions in each of the subbays of Cobscook Bay. Profiles indicative of at least four points during the tide cycle should be gathered during spring, summer, and fall seasons.

Surface water samples should be taken within the bay for total coliform and fecal coliform bacteria at four times during the tide cycle during spring, summer, and fall. Additionally, surface samples for turbidity pesticides, and PCB's should be gathered.

Spring, summer and fall samples should also be gathered throughout the bay from about six levels in the water column. These should be taken at four points in the tide cycle. Analyses performed should include: total suspended solids, volatile suspended solids, organic nitrogen, ammonia nitrogen, nitrate plus nitrite nitrogen, total phosphorus, mercury, lead, cadmium and selenium.

It is estimated that approximately 26 stations would be needed for water quality profiles, and 18 of these would be sampled for detailed chemical analyses. Seven stations in the vicinity of the proposed embankments would be used for the analysis of bottom sediments.

During construction, the resuspension of bottom sediments will take place. Therefore the characteristics of these sediments should be assessed. Tests to be performed should include: visual classification, sieve analysis, hydrometer, apparent specific gravity, pH, chemical oxygen demand, total kjeldahl nitrogen, oil and grease, percent volatile solids, radioactivity, arsenic, cadmium, copper, lead, mercury, nickel, vanadium, zinc, chromium, PCB's, DDT and C-H-N ratio for silts and clays only.

Aerial photographs or other means should be utilized to determine the amount of icing, if any, that takes place on the bay during the winter months. Since some icing would be expected during post construction conditions this comparison could prove valuable.

Future conditions in Cobscook Bay cannot be accurately predicted without the aid of modeling. Because of the extremely dynamic situation existing in the bay, the complex geometry and extreme tide range, no "off the shelf" computer model can be utilized to make definitive predictions.

If this study continues and tidal power is found to be feasible it is recommended that a physical model of Cobscook Bay be developed. This model will be constructed and calibrated using data gathered in the previously mentioned baseline studies and other supplemental data. This model would be capable of simulating the action of tides in the bay. Currents, mixing, and stratification could be predicted.

A mathematical model would then be developed based upon the physical hydrodynamic model. The use of a mathematical model would allow for the variation of operating schemes and project layout. Many different simulations for varying conditions could take place using the mathematical model. This would not be practical using the physical model.

Additionally some separate type of modeling effort, likely mathematical, will have to be conducted to determine the amount of increase in tide levels which could be expected in the Bay of Fundy and the Gulf of Maine as a result of blocking off Cobscook Bay. It is not felt that a substantial increase will occur, however, this question should be addressed.

## V. CONCLUSION

### Discussion

Unlike earlier recent studies in 1977 and 1979 (references 30 and 33), this study does not exclusively address economic evaluation of the concept of Tidal Power at Cobscook Bay Maine. Environmental and certain social concerns have been identified. The issues of intergratability and marketability of tidal power projects have been discussed.

Like the earlier studies, using a method of economic analysis which takes into account the changing costs of the fuels utilized for power generation in New England, this study concludes that, at some point after a tidal power project is built net positive benefits will accrue. This is not surprising. New England is highly dependent on oil for electric energy and will be for the foreseeable future. Oil resources of the world are not limitless. Even in the absence of eco-political forces like OPEC, oil would get scarcer and, therefore, more expensive each day. At some point in the future, 20, 50, 100 or 200 years from now oil will not be available at any price. It is safe to assume that as long as New England has a large amount of oil derived electric energy, that electric prices will continue to rise along with fuel costs.

There is no doubt then, if one assumes that the alternative to Cobscook Bay Tidal Power will always be an oil-fired combined cycle facility that the tidal power project will ultimately prove to be a worth while investment. Had the tidal power project been completed in 1935 it would be producing energy for than 10 mills/kwh today.

The question of economic attractiveness at a future time is a two-part question.

1. If prices of fuel escalate, will the project be economically feasible and marketable?
2. Will technological breakthroughs stop or drastically reduce fuel price escalation?

The report answers part of the first question and none of the second question. If fuel prices continue to escalate in accordance with published price projections the project is economically feasible. No studies have been made to assess market conditions for electric energy in the 1995 time frame. It is not known whether consumers will be willing to pay a price which will allow the Government to repay itself for its initial investment. No studies as to the timing of any potential breakthroughs in nuclear fusion or solar technologies have been attempted. These issues, the market conditions in 1995 and the time of occurrence of major technological breakthroughs (substitution and early obsolescence) are difficult to resolve. Even after extensive study any projections would be highly uncertain. It is the uncertainty inherent to these issues that

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makes the long term (100 year), capital intensive (more than \$700,000,000), investment in tidal hydropower a risky venture. It is quite possible that the Federal Government might not repay itself over the useful life of the project.

However, based on current Federal guidelines for evaluation of water resources projects tidal hydropower at Cobscook Bay, Maine, is economically feasible. It has also been established that from an electrical and operational viewpoint the sources of intermittent single pool tidal power project energy could be absorbed and utilized by New England.

Several environmental considerations have been addressed and some possible environmental impacts have been identified. Significantly, Cobscook Bay has one of the largest Bald Eagle populations in the Northeast. Other rare and endangered species observed in the area include several types of whales, the shortnose, sturgeon and the Atlantic peregrine falcon. Some unique features of the bay which result directly from the large tidal fluctuations and the accompanying currents might be adversely affected by a project. For example, ice might form on the now essentially ice free bay, dissolved oxygen content in water might decrease, stratification might occur, intertidal habitat would be decreased, the bay's value as a winter feeding ground for birds might be affected. Movements of fish and marine mammals might be hampered. The entire relatively unique eco-system of the bay would change somewhat. In general, it was found that the larger the impounded bay area, the greater the potential environmental impacts would be. No environmental impacts have been positively identified as yet.

Social impacts due to the project are felt to be most severe during construction of the project. The influx of construction workers would tax existing service and housing facilities. The noise and associated at-site congestion will also be a factor within the study area. Three major potential long term socio-economic impacts are foreseen at this time; increased tourism due to the presence of the unique project, increased interaction between Lubec and Eastport due to the possibility of shortened overland route (the dams) between them, and the most significant long term socio-economic impact in the region would be the annual addition of 500 to 700 million kilowatt hours of electrical energy derived from native, renewable resources.

#### Summary

The tidal power project has been found to be economically feasible using current Water Resources Council criteria, no insurmountable environmental impacts or technical problems have been identified, relatively favorable long term socio-economic impacts have been identified and the tidal power project would reduce New England's (and the Nation's) dependence on oil while increasing energy independence.

**REVIEW DRAFT**

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A BRIEF CHRONOLOGY — COBSCOOK BAY TIDAL POWER STUDY

March 1975	Senator Muskie's resolution to reevaluate Passamaquoddy with latest technology.
September 1976	Governor Longly requested that we study Passamaquoddy using life cycle analysis.
November 1976	Preliminary economic feasibility study- Passamaquoddy.
April 1977	Revised preliminary economic report on Passamaquoddy including life cycle analysis and a look at some all American Projects.
July 1977	OCE provided guidance on life cycle analysis and directed us to look at relative price shifts, only not taking into account general inflation.
September 1977	OCE authorized us to prepare the POS and proceed with caution, carefully evaluating economics along the way.
May 1978	Canadians decided not to participate in the study.
July 1978	Initial public meetings on Cobscook study.
September 1978	Draft Plan of Study.
December 1978	Preliminary designs; transmission BPA; powerhouse S&W.
March 1979	Final Plan of Study.
March 1979	Preliminary Economic Report (13 alternatives).
June 1979	Directive from OCE to prepare a more complete reconnaissance report addressing marketing, power integration, and environment.
August 1979	Public release of Preliminary Report and announcement of findings after briefing Senator Muskie.
November 1979	Economic Conference on Relative Price Shift Analysis - Utilities and Academics of Maine, concurred with reservations on the method.

November 1979

Water Resources Council's Principles and Standards were revised and now include relative price shift economic analysis for power projects.

August 1980

Reconnaissance Report.

ABRIDGED  
CORRESPONDENCE APPENDIX

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● Governor Brennan	21 November 1979	Review Comments - Preliminary Report on the Economics of the Project
● Department of Energy Bonneville Power Administration	4 March 1980	Transmission Costs
● Governor Brennan	5 March 1980	General Comments
● Department of Energy Southeastern Power Administration	31 March 1980	Comments on Marketing
● New England Power Planning (NEPOOL)	3 July 1980	Load and Growth Data and Comment on Integrating
● Department of Energy Federal Energy Regu- latory Commission	29 August 1980	Power Values



JOSEPH E. BRENNAN  
GOVERNOR

STATE OF MAINE  
OFFICE OF THE GOVERNOR  
AUGUSTA, MAINE  
04888

November 21, 1979

Col. Max B. Scheider  
Division Engineer  
Department of the Army  
New England Division  
Corps of Engineers  
424 Trapelo Road  
Waltham, Massachusetts 02154

Dear Colonel Scheider:

The purpose of this letter is to comment upon the Army Corps' most recent analysis regarding the Cobscook Bay Tidal Project.

I have asked the Maine Office of Energy Resources and the Maine State Planning Office to review and analyze your "Preliminary Report on the Economic Analysis of the Project", along with previous studies of the Cobscook Bay Tidal project, the "Draft Plan of Study" of September 1978, and other aspects of proposed tidal power development in Passamaquoddy and Cobscook Bays in Maine. In addition, we have reviewed the independent analysis of the project report by Dr. Normand Leberge, Director of the Half-Moon Cove Tidal Power Project for the Pleasant Point Reservation of the Passamaquoddy Tribe. Based upon our analysis I would like to offer the following comments:

First, I believe that more value should be placed on an energy source that is not dependent on non-renewable fuels and that the relative "inflation proofing" that construction of a tidal project would provide should be stressed in any comparative economic analysis. While this "relative price shift" analysis is a step in the right direction and an improvement over conventional static economic analysis, I do not believe that the technique has been carried far enough.

Secondly, I am a little puzzled by the statement in your letter that further economic analysis in July, following the (then) most recent escalation in the cost of oil by OPEC nations, "did not increase the net benefits sufficiently for economic justification." Reference to page iii of the executive summary of the preliminary report indicates a substantial improvement in the benefit cost ratio to nearly 1 at the 3% differential fuel escalation rate, and to about 1.25 at the 5% differential fuel escalation rate for the five alternative proposals listed. It is my understanding that the Army Corps of Engineers has no authority under existing standards and guidelines to evaluate projects, or to recommend continued study, at these differential fuel escalation rates. In this regard, it is interesting to note that many responsible Federal officials, including the U.S. Department of Energy, are forecasting fuel costs to rise at 4-5% above the general rate of inflation through 1990.



Col. Max B. Scheider  
November 21, 1979  
Page 2

I am concerned that your preliminary economic analysis to date has, apparently, merely considered the energy benefits of the project without regard for socio-economic benefits, mariculture opportunities, technology demonstration benefits, and a host of other benefits that would be derived from this project. Such narrow consideration of project benefits seems to run counter to other projects that your division has studies, and to Federal guidelines in this area.

Finally, I am concerned that your analysis limited the "life-cycle" effects to relative price shifts of petroleum fuels, whereas true life-cycle costing would consider such other effects as the cost of replacement structures (35-40 year life for fossil plant equipment vs. 100+year life for tidal or hydro plants).

In summary, I find numerous areas in your analysis in which we are in disagreement, and I would appreciate an opportunity to pursue this further.

I have asked John Joseph of the Maine Office of Energy Resources (OER) to contact your agency to review these points in greater detail.

I understand the Army Corps is working with the OER and the Center for Balanced Growth to arrange a meeting to discuss a number of these concerns. I hope that meeting proves productive in terms of improving the long term energy planning process.

I look forward to working with you on this and various other matters of interest to the State of Maine.

Sincerely,

  
JOSEPH E. BRENNAN  
Governor

JEB/sc

CC: Allen Pease, State Planning Office  
John Joseph, Office of Energy Resources  
Don Larrabee, Maine Office of the Governor - Washington, D.C.  
Maine Congressional Delegation



Department of Energy

Bonneville Power Administration  
P.O. Box 3621  
Portland, Oregon 97208

In reply refer to: EOFD

Mr. Robert LeBlanc, Study Manager  
Cobscook Bay Tidal Power Study  
U.S. Army Corps of Engineers  
424 Trapelo Road  
Waltham, Massachusetts 02154

Dear Bob:

In response to your request, attached is a table of investment and annual cost estimates for the transmission facilities needed to integrate 200 MW of tidal power generation from Cobscook Bay into the New England transmission grid. The interest rate used in developing the annual costs and IDC is 7-1/8%. O&M costs are based on actual O&M costs for similar facilities on the BPA system.

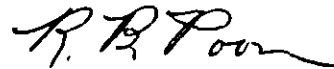
For a generating capacity of 200 MW, the integrating transmission will most likely be either 230-kV or 345-kV. The investment cost of a 345-kV system is comparable to that of a 230-kV system. The 230-kV alternative has lower line costs but greater substation costs. Since transmission losses will be lower for 345-kV, we have assumed a 345-kV system in developing the cost estimates. Peak losses are in the order of 1.5% for a 345-kV system and 4.0% for a 230-kV system.

A 345-kV system will also have the advantage of not introducing a new voltage level into the area (115-kV and 345-kV being the existing voltage levels). A sketch of the integrating transmission system is attached. The system includes a 69-kV line from the project to Calais.

We have not included any facilities for transformation at Epping because it is not certain that the cost of these facilities should be part of the project cost. Also the need for such facilities has not been thoroughly investigated. However, the addition of a 345/115-kV transformer bank at Epping will improve the reliability of service to that area.

We hope the information we are providing will satisfy your needs. Let us know if you have any questions concerning these cost estimates.

Sincerely,

A handwritten signature in cursive script, appearing to read "R. B. Poon".

R. B. Poon  
Electrical Engineer

Enclosure (2)

Cobacook Bay Tidal Power Project

**Cost Estimates - Transmission Facilities**  
**(7 1/8% Interest Rate)**

	<u>Investment (\$000)</u>			<u>Annual Cost (\$000)</u>		
	<u>Construction</u>	<u>IDC</u>	<u>Total</u>	<u>I&amp;A</u>	<u>O&amp;M</u>	<u>Total</u>
<u>Lines</u>						
Quoddy- Orrington 345-kV WHF (111 miles)	20,000	3,340	23,340	1,790	200	1,990
Quoddy-Calais 69-kV WHF (30 miles)	4,000	670	4,670	360	40	400
Subtotal	24,000	4,010	28,010	2,150	240	2,390
<u>Substation Facilities</u>						
Quoddy - 345/69 kV Transformer	3,100	520	3,620	300	40	340
2-345-kV PCB's	1,500	250	1,750	150	50	200
Calais - 69-kV PCB	150	30	180	20	10	30
Orrington - 2-345-kV PCB's	1,500	250	1,750	150	50	200
Subtotal	6,250	1,050	7,300	620	150	770
<u>Power System Control</u>	1,000	170	1,170	110	50	160
Total	31,250	5,230	36,480	2,880	440	3,320

**Note:**

Service Life: Lines (WHF) 38 yrs  
Substation 28 yrs  
PSC 20 yrs

IDC @ 7 1/8% interest: 16.7% of construction cost

Bonneville Power Administration  
Branch of System Engineering  
March 4, 1980



RBP  
3-5-80



JOSEPH E. BRENNAN  
GOVERNOR

STATE OF MAINE  
OFFICE OF THE GOVERNOR  
AUGUSTA, MAINE  
04888

March 5, 1980

Colonel Max B. Scheider  
Division Engineer  
New England Division  
Corps of Engineers  
424 Trapelo Road  
Waltham, Massachusetts 02154

Dear Col. Scheider:

I appreciated the briefing which you and your staff provided me on Monday, 21 January 1980, relating to energy projects for Maine which are currently under study by your Division.

I believe that Maine's future energy needs will be well served by continuation of St. John River Basin Study with emphasis on Masardis and Castle Hill hydro potential on the Aroostook River. In addition, I support a continuation of the tidal power study at Cobscook Bay. I believe that project economics of alternatives under consideration although marginal at this time, will in my view improve with the increasing costs of alternative fossil fuels. Further, the latest economic analysis as now permitted by recently issued Principles and Standards relating to "Relative Price Shifts" could well move the project into economic justification.

Regarding the important and significant Dickey-Lincoln project, I look with much interest upon the Corps completion of the mitigation planning which will finalize environmental evaluation and Environmental Impact Statement so that an objective decision can be made as to proceeding with construction of this important hydro project.

My thanks to you and your staff for your informative briefing, and be assured I will work with you to further these projects.

Sincerely,

  
JOSEPH E. BRENNAN  
Governor

JEB/sc



Department of Energy  
Southeastern Power Administration  
Elberton, Georgia 30635

March 31, 1980

Mr. Joseph L. Ignazio  
Chief, Planning Division  
New England Division  
Corps of Engineers  
Department of the Army  
424 Trapelo Road  
Waltham, Massachusetts 02154

Dear Mr. Ignazio:

This responds to your letters of January 22, 1980, and February 8, 1980, File NEDPL-H, concerning the possibility of developing a tidal hydroelectric power facility in eastern Maine near Eastport at Cobscook Bay.


Utilizing the data furnished by these letters, the energy from the project would cost an average of approximately 94 mills per kwh excluding any marketing costs. No capacity values can be found for this project.

This estimated cost of 94 mills is almost two and one-half times the FERC estimated energy value of 38 mills per kwh based on August 1979 price levels and is approximately twice the anticipated energy value estimate of 49 mills per kwh based on December 1979 oil price levels.

In light of the above comparisons, it is evident that the project is not financially feasible under existing criteria and the preparation of operating and marketing studies would not be warranted.

If the price of alternative energy continues to increase or evaluation criteria is changed, we will be happy to cooperate with you in future studies.

Sincerely,

  
Harry F. Wright  
Administrator

cc:  
Emerson Harper

# NEPLAN

## *New England Power Planning*

174 BRUSH HILL AVENUE  
WEST SPRINGFIELD, MASSACHUSETTS 01089  
TELEPHONE (413) 785-5871

July 3, 1980

Max B. Scheider  
Colonel, Corps of Engineers  
Division Engineer  
NED, Corp of Engineers  
424 Trapelo Road  
Waltham, MA 02154

Dear Colonel Scheider:

As requested in your letter of May 13, 1980 and in accordance with previous discussions held with Messrs. Guptill and LeBlanc of your office we are enclosing the following data for use in evaluating your tidal hydro project at Cobscook Bay.

- Exhibit 1. Hourly loads and actual non oil-fired dispatch of pool generation for the winter peak load day of Dec. 19, 1979.
- Exhibit 2. Hourly loads and actual non oil-fired dispatch of pool generation for the summer peak load day of Aug. 2, 1979.
- Exhibit 3. Hourly loads and actual non oil-fired dispatch of pool generation for typical Spring and Fall days of 1979, viz, April 18th & Oct. 10th.
- Exhibit 4. Generation plant data showing unit type, dispatch priority, average full load cost in \$/MWH (parameters are: fuel cost, unit heat rate, and transmission penalty factors to the New England Center).
- Exhibit 5. Forecasted 1995 hourly loads for the winter, summer, spring, and fall for the peak day and for a typical weekday.
- Exhibit 6. Anticipated 1995 winter thermal priority list of Nuclear & Coal fired generation.

With respect to additions to the generating system through January 1996, we suggest you refer to the "New England Load and



Capacity Report, 1980-1995" copies of which were furnished to your personnel at our office recently. Please use only the authorized units as noted on page 55, Appendix B. Exhibit #6 indicates the addition of the 4-1150 nuclear units and the Sears Island coal unit.

With respect to the fuel costs, those shown on the enclosed exhibits are current 1980 costs. Forecasting of costs to 1995 is left to your own methods and trending procedures.

In regards to scheduled maintenance for your 1995 energy replacement study, we suggest you assume the average availability rates indicated on Exhibits 4 & 6 for determining the amount of thermal capacity required to meet the load for all periods of the year. We anticipate, with adequate funding and favorable EPA decisions, that several more existing units will be burning coal by 1995. These units are shown on Exhibit 6 with the appropriate availability rates. Those units still burning oil in 1995 should follow the coal units in the thermal priority list maintaining the same relative priority ranking they have to each other on Exhibit 4.

With respect to the output from the proposed tidal project, we concur that the capacity could not be considered dependable because of the inability to time the output with the daily load demands.

We anticipate no problems in integrating the energy from the proposed tidal project into the total New England load. However, studies would have to be made with respect to details of the specific electrical intertie and the operational impact on the local utility's system.

As discussed with Mr. LeBlanc, by Mr. Ferreira on July 2, our office will be available for clarification and response to questions on the enclosed data and for further detail with respect to your study.

Sincerely,



Arthur W. Barstow  
Manager, Generation Planning

AF/AWB/jel  
enc.

c.c. NEPOOL Planning Committee (letter only)  
A. Ferreira

FEDERAL ENERGY REGULATORY COMMISSION  
NEW YORK REGIONAL OFFICE  
26 FEDERAL PLAZA  
NEW YORK, NEW YORK 10007

August 29, 1980

Colonel Max B. Scheider  
Division Engineer  
Corps of Engineers  
Department of the Army  
424 Trapelo Road  
Waltham, Massachusetts 02154

Dear Coloner Scheider:

In accordance with your letter of December 4, 1979 and your subsequent submittal of May 8, 1980, we have calculated at-market power values for the Cobscook Bay Tidal Power Project. The power values are calculated for the 38.7 percent capacity factor Birch configuration only. The same power values apply to the 38.6 percent capacity factor Goose configuration. This is in accordance with a May 1, 1980 telephone conversation between Mr. F. Craig Zingman of this office and Mr. Robert Le Blanc of your office.

The Cobscook Bay Project has been analyzed on a life cycle cost basis for the one hundred year period beginning with the expected project on line date of 1995. We note that the electrical output of the two single pool projects is controlled by the tide and electrical power is available at approximately 13-hour intervals, for relatively short periods, and at varying peak outputs. The availability of power from the project would concur with periods of peak utility demand only once every several days. For this reason, the capacity value (dollars per kilowatt-year) has been taken to be zero. The energy value represents the total value of Cobscook Bay and reflects the displacement value of energy from oil-fired generating units from 1995 through 2095.

The cost of the oil fuel displaced by the Cobscook Bay Project was escalated in accordance with the Department of Energy-Office of Conservation and Solar Energy tables which were published in the Federal Register on January 23, 1980. This DOE table is based upon constant dollars and the oil prices shown are escalated from 1980 through 2010 at a rate above the general rate of inflation. Ater that, fuel prices were assumed to increase along with the general rate of inflation, i.e., no increase using the

constant dollar method (see the attached Figure 1). All displaced energy costs were discounted to the year 1995, using the federal interest rate of 7-1/8 percent and the private interest rate of 11.5 percent. These discounted costs were summed and then multiplied by the one hundred year capital recovery factor appropriate to each interest rate. The power values are shown below:

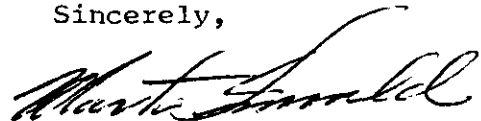
Cobscook Bay Power Values

	<u>Capacity Value</u> (\$/kW-Yr)	<u>Energy Value</u> (Mills/kW hr.)
Federal Cost of Money 7-1/8%	0	108
Private Cost of Money 11-1/2%	0	104

It should be noted that, since these power values were calculated on the constant dollar basis, they are comparable to project construction cost estimates calculated on the same basis for the 1980 through 1995 period.

Should you have any questions concerning these power values or our method of calculations, please call Mr. F. Craig Zingman on FTS - 264-1163.

Sincerely,



Martin Inwald  
Acting Regional Engineer

Enclosure  
as stated

FIGURE 1

DISCOUNTING METHODOLOGY  
REAL FUEL ESCALATION

